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U. S. DEPARTMENT OF AGRICULTURE
WEATHER BUREAU
CHARLES F. MARVIN, Chief

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NOTICE TO CONTRIBUTORS.

Contributions intended for publication in any given issue of the MONTHLY WEATHER REVIEW (e. g., January) should be in the hands of the Editor before the end of the next following month (e. g., February), if no illustrations are required. When the paper is illustrated, the manuscript and the copy for the illustrations must be submitted much earlier, in order to permit copy being prepared for the engraver by the end of the month.

REPRINTS are made up without covers in the original size and pagination of the REVIEW. They will not be furnished unless specifically REQUESTED WHEN THE MANUSCRIPT IS SUBMITTED.

MONTHLY WEATHER REVIEW

CLEVELAND ABBE, jr., Acting Editor.

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INTRODUCTION.

As explained in this Introduction during 1914, the MONTHLY WEATHER REVIEW now takes the place of the Bulletin of the Mount Weather Observatory and of the voluminous publication of the climatological service of the Weather Bureau. The MONTHLY WEATHER REVIEW contains contributions from the research staff of the Weather Bureau and also special contributions of a general character in any branch of meteorology and climatology.

SUPPLEMENTS to the MONTHLY WEATHER REVIEW will be published from time to time.

The climatological service of the Weather Bureau is maintained in all its essential features, but its publications, so far as they relate to purely local conditions, are incorporated in the monthly reports "Climatological Data" for the respective States, Territories, and colonies.

Beginning August, 1915, the material for the MONTHLY WEATHER REVIEW will be prepared and classified in accordance with the following sections:

SECTION 1.—*Aerology.*—Data and discussions relative to the free atmosphere.

SECTION 2.—*General meteorology.*—Special contributions by any competent student bearing on any branch of meteorology and climatology, theoretical or otherwise.

SECTION 3.—*Forecasts and general conditions of the atmosphere.*

SECTION 4.—*Rivers and floods.*

SECTION 5.—*Seismology.*—Results of observations by Weather Bureau observers, and others as reported to the Washington office. Occasional original papers by prominent students of seismological phenomena.

SECTION 6—*Bibliography.*—Recent additions to the Weather Bureau library; recent papers bearing on meteorology.

SECTION 7.—*Weather of the month.*—Summary of local weather conditions; climatological data from regular Weather Bureau stations; tables of accumulated and excessive precipitation; data furnished by the Canadian Meteorological Service; monthly charts Nos. 1, 2, 3, 4, 5, 6, 7, 8, the same as hitherto; Meteorological Summary and chart No. 9 of the North Atlantic Ocean for this month in 1914. Owing to the fact that ocean meteorological data are frequently not available for a considerable time after the close of the month to which they relate, the chart and text matter in connection therewith appear one year late.

In general, appropriate officials prepare the seven sections above enumerated; but all students of atmospherics are cordially invited to contribute such additional articles as seem to be of value.

The voluminous tables of data and text relative to local climatological conditions that during recent years were prepared by the 12 respective "district editors" are omitted from the MONTHLY WEATHER REVIEW, but collected and published by States at selected section centers.

The data needed in section 7 can only be collected and prepared several weeks after the close of the month designated on the title page; hence the REVIEW as a whole can only issue from the press within about eight weeks from the end of that month.

It is hoped that the meteorological data hitherto contributed by numerous independent services will continue as in the past. Our thanks are specially due to the directors and superintendents of the following:

The Meteorological Service of the Dominion of Canada,
The Meteorological Service of Cuba,
The Meteorological Observatory of Belén College, Habana,
The Government Meteorological Office of Jamaica,
The Meteorological Service of the Azores,
The Meteorological Office, London,
The Danish Meteorological Institute,
The Physical Central Observatory, Petrograd,
The Philippine Weather Bureau.

CORRIGENDA.

In this REVIEW, November, 1915:

Page 551, column 1, last line, after Salvador *read:* [$\varphi = 24°$ N., $\lambda = 74°$ W.].
Page 554, column 2, line 7 from bottom, *for* (−180°C. . . .) *read:* (−80°C. . . .).
Page 573, column 2, last paragraph, *for* (. . . p. —) *read:* (. . . p. 572).

25808—16——1

SECTION I.—AEROLOGY.

SOLAR AND SKY RADIATION MEASURED AT WASHINGTON, D. C., DURING DECEMBER, 1915.

By HERBERT H. KIMBALL, Professor of Meteorology.

[Dated: Washington, D. C., Jan. 17, 1916.]

In Table 1 are summarized the measurements of the intensity of direct solar radiation made by the Weather Bureau at the American University,[1] Washington, D. C., during December, 1915. The means for the month are somewhat lower than the five-year means for December published in the Bulletin of the Mount Weather Observatory, **5**:182, Table 3, and markedly lower than those for December, 1914, published in the REVIEW for December, 1914, **42**:648.

Skylight polarization, measured at solar distance 90° and in his vertical, with the sun at zenith distance 60°, averaged 60 per cent, with a maximum of 66 per cent, which is 3 per cent higher than the average monthly maximum for December published in the Bulletin of the Mount Weather Observatory, **3**:114, Table 16.

TABLE 1.—*Solar radiation intensities at Washington, D. C., during December, 1915.*

[Gram-calories per minute per square centimeter of normal surface.]

Date.	Sun's zenith distance.										
	0.0°	48.3°	60.0°	66.5°	70.7°	73.6°	75.7°	77.4°	78.7°	79.8°	80.7°
	Air mass.										
	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5	6.0
1915.											
A. M.	Gr.-cal.	Gr.-cal.	Gr.-cal.	Gr.-cal.	Gr.-cal.	Gr.-cal.	Gr.-cal.	Gr.-cal.	Gr.-cal.	Gr.-cal.	Gr.-cal.
Dec. 1				1.17	1.11	1.05					
2			1.14								
3								0.76	0.68	0.60	0.53
4			0.89	0.77	0.67	0.60	0.52	0.44	0.38	0.35	0.30
6			1.31	1.25							
7				1.16	1.09	1.03	0.96	0.90	0.83	0.77	0.72
15					1.16	1.08	0.99	0.93	0.88	0.83	0.78
16			1.18								
19			1.12								
21			1.03	0.95	0.82	0.70	0.63	0.56	0.49	0.44	0.40
23							0.78	0.73	0.67	0.62	0.56
24			1.28				0.98	0.92			
26			1.31	1.24	1.17						
30			1.11	0.96	0.89						
Means			**1.15**	**1.07**	**0.99**	**0.89**	**0.81**	**0.75**	**0.66**	**0.60**	**0.55**
P. M.											
Dec. 7				1.10	1.02	0.95	0.88	0.81	0.74	0.68	0.63
15				1.24	1.18	1.12	1.05	0.99	0.93		
21				1.04	1.01	0.86	0.77	0.72	0.67	0.62	0.57
22							0.89	0.81	0.74	0.68	
30				0.94	0.77	0.59					
Means				**1.06**	**1.00**	**0.88**	**0.90**	**0.83**	**0.77**	**0.66**	(0.60)

In Table 2, column 2 gives the daily totals of solar and sky radiation received on a horizontal surface at the American University during December, 1915. The measurements were made with a Calendar recording pyrheliometer, as described in the REVIEW for March, 1915, **43**:100. Table 2, column 3, gives the daily departures from the normals published in the same number of the REVIEW, page 111, Table 4. A deficiency of radiation is shown for every decade of the month.

[1] For a description of exposures of instruments and details of methods of observation, see this REVIEW, December, 1914, 42:648.

The "Percentage of possible sunshine" and the "Average cloudiness," given in columns 5 and 6 of Table 2, have been taken from the records of the observatory at the central office of the Weather Bureau. The monthly mean percentage of possible sunshine is 51, which is also the normal for Washington for December. The deficiency in the total radiation for the month is therefore to be attributed to low radiation intensities, as indicated by Table 1, rather than to excessive cloudiness.

TABLE 2.—*Daily totals and departures of solar and sky radiation at Washington, D. C., during December, 1915.*

[Gram-calories per square centimeter of horizontal surface.]

Date.	Daily totals.	Departure from normal.	Excess or deficiency since first of month.	Percentage of possible sunshine.	Average cloudiness.
	Gr.-cal.	Gr.-cal.	Gr.-cal.	Per cent.	0-10.
December 1	188	10	10	54	7
2	126	− 50	− 40	23	8
3	163	− 12	− 52	55	6
4	174	1	− 51	76	3
5	187	15	− 36	70	5
6	182	11	− 25	54	6
7	223	52	27	100	0
8	64	−106	− 79	17	8
9	116	− 54	−133	36	7
10	202	33	−100	79	2
11	184	15	− 85	63	6
12	94	− 74	−159	4	10
13	103	− 65	−224	6	9
14	159	− 8	−232	55	6
15	234	67	−165	100	0
16	177	11	−154	46	8
17	41	−125	−279	0	10
18	78	− 88	−367	45	7
19	209	44	−323	100	1
20	193	28	−295	55	7
Decade departure			**−195**		
21	206	41	−254	100	0
22	173	8	−246	60	3
23	154	− 10	−256	60	5
24	187	23	−233	71	4
25	127	− 37	−270	30	9
26	256	92	−178	100	1
27	189	25	−153	83	6
28	61	−102	−255	0	9
29	39	−124	−379	2	9
30	193	30	−349	76	3
31	112	− 52	−401	4	10
Decade departure			**−106**		
Total excess or deficiency since first of year			**−1882**		

SOLAR RADIATION INTENSITIES AT SANTA FE, N. MEX., DURING SEPTEMBER, NOVEMBER, AND DECEMBER, 1915.

By HERBERT H. KIMBALL, Professor of Meteorology.

[Dated: Washington, Jan. 18, 1916.]

The measurements summarized in Table 1 are in continuation of those published in the REVIEW for September, 1915, **43**: 439–443, except that on November 1, 1915, Mr. Lee R. Grabill, jr., was detailed as an additional assistant at Santa Fe, and since that date has made all the pyrheliometric readings.

It will be noted that in all three months the readings average higher than the means for the corresponding months published in the September REVIEW above referred to. Also, those for September 27, with the sun at zenith distance 48.3° or more, those for November 12, with the sun at zenith distance 60° or more, and all those for December 24, are higher than any previous corresponding readings at Santa Fe in a month with the same name.

TABLE 1.—*Solar radiation intensities at Santa Fe, N. Mex., during September, November, and December, 1915.*

[Gram-calories per minute per square centimeter of normal surface.]

Date.	Sun's zenith distance.										
	0.0°	48.3°	60.0°	66.5°	70.7°	73.6°	75.7°	77.4°	78.7°	79.8°	80.7°
	Air mass.										
	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5	6.0
A. M.	Gr.-cal.	Gr.-cal.	Gr.-cal.	Gr.-cal.	Gr.-cal.	Gr.-cal.	Gr.-cal.	Gr.-cal.	Gr.-cal.	Gr.-cal.	Gr.-cal.
September 27	.....	1.48	1.43	1.37	1.29	1.21	.....	.....	.....	.....	.....
A. M.											
November 4	.....	1.52	1.47	.....	.....	.....	.....	.....	.....	.....	.....
5	.....	1.53	1.48	.....	.....	.....	.....	.....	.....	.....	.....
8	.....	.....	1.51	1.42	1.33	1.25	1.18	.....	.....	.....	.....
11	.....	1.63	1.56	1.49	1.42	1.36	1.30	.....	.....	.....	.....
12	.....	1.66	1.61	1.55	1.48	1.42	1.36	1.32	.....	.....	.....
13	.....	1.58	1.49	1.39	1.26	1.17	1.13	.....	.....	.....	.....
15	.....	.....	1.53	1.43	.....	.....	.....	.....	.....	.....	.....
17	.....	1.63	1.55	1.47	1.35	1.30	1.22	.....	.....	.....	.....
18	.....	1.63	1.54	1.46	1.38	1.31	1.29	1.25	1.21	.....	.....
20	.....	1.57	1.52	1.43	1.38	1.32	1.26	1.22	1.17	.....	.....
23	.....	.....	1.47	.....	.....	.....	.....	.....	.....	.....	.....
26	.....	.....	1.53	1.46	1.39	1.33	1.27	.....	.....	.....	.....
29	.....	.....	1.51	1.44	1.38	.....	.....	.....	.....	.....	.....
30	.....	.....	1.46	.....	.....	.....	.....	.....	.....	.....	.....
Means	.....	1.59	1.52	1.45	1.37	1.31	1.25	1.26	(1.19)	.....	.....
A. M.											
December 1	.....	.....	1.51	1.43	1.34	1.27	1.22	1.17	1.12	.....	.....
3	.....	.....	1.53	1.44	.....	.....	.....	.....	.....	.....	.....
7	.....	.....	1.52	1.44	1.35	1.27	1.20	1.12	.....	.....	.....
8	.....	.....	1.52	1.44	1.40	.....	.....	.....	.....	.....	.....
9	.....	.....	.....	.....	.....	.....	1.31	1.19	.....	.....	.....
11	.....	.....	1.47	.....	1.29	.....	.....	1.16	1.13	.....	.....
17	.....	.....	1.56	1.48	1.40	1.33	.....	.....	.....	.....	.....
21	.....	.....	.....	1.43	1.36	1.27	1.23	.....	.....	.....	.....
22	.....	.....	1.49	1.42	1.36	1.31	1.21	1.13	.....	.....	.....
23	.....	.....	.....	1.38	.....	.....	.....	.....	.....	.....	.....
24	.....	.....	1.59	1.53	1.43	1.35	1.30	1.20	.....	.....	.....
Means	.....	.....	1.52	1.44	1.37	1.30	1.24	1.16	(1.12)	.....	.....

A HALO IN THE MAKING.

By J. R. WEEKS, Local Forecaster.

[Dated: Binghamton, N. Y., June 28, 1915.]

At Binghamton, N. Y., on December 18, 1914, occurred one of those peculiar mornings when the cold air settles in the Susquehanna and Chenango River Valleys, which here run north and south, and abnormal cold is experienced, accompanied by a deposit of hoarfrost. The temperature on this occasion fell to −7°F. at 8 a. m., while neighboring cities in New York and New England at the same hour had much higher temperatures, as shown in Table 1.

TABLE 1.—*Temperatures, December 18, 1914, to nearest whole even degrees at New York and New England stations.*

	Lowest.	At 8 a. m.		Lowest.	At 8 a. m.
	°F.	°F.		°F.	°F.
Binghamton, N. Y.	−8	−7	Canton, N. Y.	14	18
Ithaca, N. Y.	4	4	Scranton, Pa.	4	4
Syracuse, N. Y.	8	8	New York, N. Y.	18	18
Rochester, N. Y.	10	10	Albany, N. Y.	10	10
Buffalo, N. Y.	12	12	Northfield, Vt.	−6	−4
Oswego, N. Y.	14	14	Boston, Mass.	16	18

Usually such a condition does not occur unless the center of high barometer, which brings the clear sky and increased nocturnal radiation, is located over or north of this locality. But in this instance the center of high pressure was on the North Atlantic coast.

The hoarfrost began to gather on the trees and exposed objects before sunrise and remained until about 11 a. m., being heaviest just after sunrise. The temperature did not begin to rise until about 10:15 a. m. The rivers were covered over much of their course with ice, but there were numerous open spaces where the swiftness of the current prevented ice formation. In such localities mist wreaths rose from the water to a height of 4 to 15 feet and then disappeared in the air. Only a portion of the hoarfrost and fog is believed to have reached the air from this source, the remainder being condensed from the air itself. The mist ceased rising from the water at about 11 a. m. The average depth of snow on the ground was 8 inches.

The light fog began to form before sunrise, probably when the temperature reached the neighborhood of 0°F., and continued in the air all day, though it was not very noticeable after noon. It reached a maximum density at about 8:30 a. m. At that time objects a thousand feet distant were visible, but the landscape beyond merged into a white obscurity. The hills, distant a half mile, were invisible and the white fog rose from the horizon to an elevation of 20° to 25°, gradually blending into the milky blue that covered the remainder of the heavens. The fog was composed of snow and ice crystals that were just at the limit of visibility to the naked eye. The general appearance of these was not that of spicules, but rather of 6-pointed star shapes of very small size. At 10:30 a. m. the fine deposit that gathered on the sidewalks was examined with a microscope and found to consist of minute 6-pointed stars.

Although hoarfrost and fog are not infrequent at this station, solar halos in connection therewith are of rare occurrence. The halo on this occasion was noticed as soon as the sun rose above the horizon, the north and south sides of the arc of 22° being bright, while the highest part of the curve was very faint. The whole circle of 22° radius was visible at 8:30 a. m. The sun itself was lost in a somewhat diamond-shaped yellowish white glare of light occupying the center of the circle. The bright portions of the halo extended below and in front of the hills about 1 mile distant, but the hills themselves were invisible. The halo had the appearance of being situated about three-fourths of a mile distant from the observer. At 8:15 a. m., the sun then being well above the horizon, the writer took position on a bridge that extended east and west and had at its southeast side a four-storied building. It was thus possible by moving along the bridge to place the building between the apparent position of the northern half of the halo and the observer, while the sun remained visible. In this position an arc of halo light remained visible against the dark background of the building and this arc corresponded with the remaining portion of the 22°-circle of the halo. By moving back and forth on the bridge this was repeatedly verified. Thus the halo was not formed on any one plane of the fog, but through a stratum of perhaps 2 or 3 miles thickness. Again, on facing the sun and looking at an angle downward toward the ground from the bridge, a vertical pillar of light was seen, somewhat faint but plainly visible. This was only noticeable against the dark background, being obscured in the sky by the general glare of light. The ice crystals in the air were visible to the eye as dancing particles of light moving in all directions, up, down, and sideways. No predominant direction of motion could be observed and it was evident that if they were spicules or prisms their planes must lie in all directions. No traces of the halo could be seen at 9:20 a. m., though fog was still present near the surface and did not entirely disappear all day. The appearance of the sky during the day was such as to apparently favor halo formation, but a close watch disclosed none.

LUNAR HALO OF JUNE 24–25, 1915, AT RICHMOND, VA.

June 24, 8:15 p. m.—An indistinct lunar halo was observed in very thin cirrus clouds and persisted until about 8:45 p. m. At 9 o'clock the vague outline of a 22°-halo was observed. The cirrus in which it appeared was then thin and fragmentary. These cirrus clouds gradually thickened until the sky became milky in appearance and the 22°-halo became very distinct. In addition two arcs were observed on either side of the moon at a distance of about 7° or 8°. These arcs were apparently portions of equal circles. Although the halo was brightest on its eastern edge no coloring was observed. The arcs were whitish in appearance and bore no resemblance to a corona. They faded about 10 p. m., and were not observed by me again. The halo was observed until about 11 p. m., at which time my view of it became obstructed.—*Thos. R. Brooks.*

9:25 p. m.—A pair of halos of concentric appearance was visible at 9:25 p. m., formed on cirri of very usual appearance, with some traces of striation from northeast to southwest. The larger of the halos was approximately 22° in radius, while the smaller one seemed to have a diameter equal to the radius of the larger. The color of both rings was of poor definition, and the only portion of chromatic distinctness was at the upper, zenithward, edge of the outer circle where a reddish hue could be detected on the inner side of the arc. A colorless paraselena, somewhat questionable, and of the shape of a luminous ear of corn, might be included in the description of the phenomenon. This was coincident with the righthand portion of the larger halo, and extended directly away from the moon.

Measurements could not be made instrumentally and the only check on size that the writer was able to establish was by comparison with estimated distances from the horizon to the lower edge and the zenith distance of the upper edge, which were 15° and 20°, respectively. The appearance at a later hour was not observed.—*C. G. Andrus.*

10:20 p. m.—An ordinary lunar halo of 22° with a distinct reddish tint on its inner side was observed at this time. The circle was nearly complete except for a small gap on its lower side. There was also at this time a well-defined corona but without pronounced colors. At 10:40 p. m. the halo was still visible.—*E. A. Evans.*

10:40 p. m. to 10:55 p. m.—When first seen the sky was practically clear, stars being visible outside of, but not within the outer circle, of which there were two. There were, however, some thin high clouds, but neither their form nor movement could be discerned with certainty. Occasionally light wisps, evidently much below the cirrus level, swept rapidly across the halo, but without taking on any iridescence or appearing in anyway to become involved with the halo.

The whole phenomenon consisted of an inner ring and an outer arc, the lower portion of which—that is, the part nearest the horizon—being missing. Both circle and arc were concentric. The general appearance of the phenomenon was a trifle lacking in definition. The disk of the moon was not sharply discernible and the outer and inner edges of the arc were somewhat blurred; especially was this true of the outer, which faded at a distance of about 1 degree from the reddish inner edge. The tint lining the arc was brightest above and to the left of the moon and there may have been a faint paraselena at that place, but its presence is doubtful in the mind of the observer. Presumably this was an ordinary halo of 22°, but from a rough approximation made by carefully sighting over a pencil and afterwards constructing the angle it appeared to have been slightly less. The inner circle measured in the same way and with as much accuracy as possible under the circumstances was considered to have been one of 9° radius and the band to have been ½° wide. This, excepting of course the moon, was the most pronounced feature of the display. Both inside and outside edges of the circle were reasonably clear cut and the circle was complete and of silvery whiteness. The whole phenomenon reached its full development at or before the time I first observed it at 10:40 p. m.; at least shortly after that time it began to dissipate, since at 10:55 p. m. only the outer arc, somewhat more blurred than before, was to be seen. At 1:00 a. m. of the 25th the large arc was again seen, this time through small wisps of clouds, possibly of the alto-cumulus or high stratocumulus type.—*J. H. Kimball.*

THE PENETRATING RADIATION PRESENT IN THE ATMOSPHERE.[1]

By A. GOCKEL.

[*Reprinted from* Science Abstracts, Sect. A, Dec. 28, 1915, §1693.]

The author briefly reviews the results obtained by other workers up to the present time, in various localities, under water, above water and ground, and at considerable heights in the atmosphere. The question of instrumental errors is taken up; the effects of changes of temperature and of humidity and of variations in barometric pressure are also considered. The author also avails himself of existing data, and those obtained from his own researches, in the endeavor to ascertain whether or not there are regular daily and also seasonal variations in the penetrating radiation. Experiments have been carried out by the author, with the aid of Wulf's "Strahler," as well as with an arrangement devised by himself, using Benndorf's electrometer (registration instrument). Measurements have been carried out at the Bodensee by balloons, above the ice of the Eiger and Grindelwald glaciers; on the Aletsch glacier, on the Eggishorn, on the snow of the Jungfrau ridge, in ice grottoes, as well as near the bare rocks; also in the propinquity of grass land and gardens in Freiburg in Switzerland, together with other places. A few only of the results can be given here. The figures denote the production of ions per cubic centimeter per second. At the Bodensee, November 12, 1913—at 1 meter above water, 13.3; at 2 meters under water, 12.7; at 4 meters, 11.6; and at 6 meters, 10.6. In a garden at Freiburg, above the turf, 11.3 (dates not given); on the Aletsch glacier, at 2,800 meters, 10.7; near the gneiss rocks of the Trugberg, 19.6; and by the mica schist on the Eggishorn, 2,200 meters, 16.8. The strongest radiation observed by the author was that in the Lötschberg tunnel, through the granite, where the measurement gave 30 ions per cubic centimeter per second.

From his investigations the author draws the following deductions: (1) A depth of water of 3.5 meters is insufficient to absorb the radiation (cosmic?) coming from the atmosphere. (2) The observations on glaciers, as also with balloon ascents, show that there is an increase of the penetrating radiation with the height. (3) From solid crystalline rocks radiation is more intense than from cultivated alluvial soil. (4) A daily oscillation of the penetrating radiation is not noticeable in

[1] Phys. Zeits., Oct. 1, 1915, **16**: 345–352.

Freiburg. (5) That portion of the radiation which comes from the earth is stronger in the warm season than in the cold. (6) The radiation coming from the atmosphere at a height over 2,200 meters shows an oscillation from day to day. Further observations on mountain tops are desirable in this connection.

It has been supposed—owing to the fact that at low elevations the production of ions is small while at great height the production is so large—that the sun is the direct source of the radiation. Against this theory is the lack of variation between day and night. It would be of interest to see how the radiation is affected during sun-spot periods and whether it is measurably influenced by the declination of the sun. On the Atlantic Ocean at a distance from the land a sensible local and temporary oscillation has been noticed to accord with that of the barometer. Lower pressure seems to favor an increase in the radiation. Again, upon approaching the land, a stronger radiation has been observed and there appears to be an oscillation corresponding daily with the periods during which the land and sea breezes prevail. These facts militate against the view that the sun is the immediate source of the penetrating radiation.—*E. O. W[alker]*.

CONCOMITANT CHANGES IN TERRESTRIAL MAGNETISM AND SOLAR RADIATION.[1]

By L. A. BAUER.

[Dated: Department of terrestrial magnetism, Washington, Nov. 17–Dec. 3, 1915.

While good progress has been made by various investigators in establishing the relationship between fluctuations of the earth's magnetism and those of the sun's activity during the sun-spot cycle, there are still outstanding a number of important questions. The magnetic quantity hitherto generally used—as, for example, one of the magnetic elements (chiefly the magnetic declination) of the range of the diurnal variation (again chiefly of the magnetic declination)—has not admitted always of direct physical interpretation, nor has it furnished always a convenient measure of the magnetic changes. Accordingly the author in a preliminary examination of this relationship, made in 1909, introduced a quantity called the "local magnetic constant," designated by G, which, under certain assumptions, is proportional to the magnetic moment of the earth or to the intensity of magnetization.

Various recent investigations have shown that the quantity G provides an adequate measure of certain changes to which the earth's magnetism is continually subject. One interesting result of the 1909 investigation was that increased solar activity, as measured by sun-spot frequencies, was accompanied apparently by a decrease in the earth's magnetic constant. This is the general effect that accompanies any large magnetic disturbance. For example, during the magnetic storm of September 25, 1909, the earth's magnetic state was below normal for a period of about 3 months. Since magnetic storms in general increase in frequency, as well as in magnitude, with increased sun-spot activity, the general effect on the magnetic constant during the sun-spot cycle is as it was found to be.

In the present paper there are considered changes in the earth's magnetism of a considerably minor order of magnitude as compared with the magnetic perturbations just discussed; however, they are found to be not less important. The precise relationship between changes in solar radiation and possible changes in the earth's magnetism could be subjected to a definite examination only when values of the solar constant, of such accuracy as those of the Smithsonian Institution, became available. Fortunately we now have a series of determinations at Mount Wilson, of this constant by Abbot for a period of four to five months during the years 1905–1914, excepting 1907. The 1913 and 1914 data were kindly supplied by him in advance of publication, for special use in connection with the present investigation. There were likewise made available the magnetic data for the same years, recorded at the observatories of the Coast and Geodetic Survey, for which acknowledgment should be made to the superintendent of that survey.

In the Balfour-Schuster theory of the diurnal variation of the earth's magnetism, it was necessary to introduce an additional hypothesis to account for the great ionization required by the theory, and solar radiation suggested itself as a possible cause. "Hence," Schuster says, "we might expect an increased conducting power in summer and in daytime as compared with that found during winter and at night." If solar radiation plays the prominent part required in the Schuster analysis of the diurnal variation of the earth's magnetism, the question naturally arises: If, at any particular moment or period, the solar radiation falling upon the earth's atmosphere suffers from some cause an appreciable increase or decrease, is there a corresponding observable magnetic change? A diminution, for example, in the amount of solar radiation could be caused by the interposition of some screening body between the sun and the earth. The interposing body might be the moon, as during a total solar eclipse, or a cooling layer above the sun's photosphere. In the first case magnetic observations made during a total solar eclipse would shed some light, and in the second case a comparison of observed values of the solar constant with concomitant magnetic records would be of great interest. We have carried out both lines of inquiry.

It is not possible to enter here into the details of all tests applied and as to methods of computation employed. It must suffice to state the chief conclusions derived to date:

a. Changes in the earth's magnetism of appreciable amount are found associated with the changes in solar radiation as shown by values of the solar constant possessing the requisite accuracy. For the average daily change in the solar constant, which amounts to about 1.5 per cent of its value, the magnetic constant used as a measure of the prevailing magnetic state of the earth suffers a change of about 0.003 per cent, or about one digit in the fifth decimal C. G. S. units. The effect on the horizontal component of the earth's magnetic force would be about twice this.

b. Decreased solar constant appears to be accompanied by increased magnetic constant and decreased diurnal range of the earth's magnetism, in accordance with the following relations: 1 per cent change in the solar constant is accompanied by a change of about 0.002 per cent in the magnetic constant and by about 1 per cent in the magnetic diurnal range. Assuming for the present a linear relation between the solar constant and magnetic changes, a 10 per cent change in the solar constant, as occasionally occurs, may be accompanied by a change in the magnetic constant of about 0.002 per cent and by about 10 per cent in the magnetic diurnal range. The magnetic effects observed during total solar eclipses are about equivalent to those which might be expected from

[1] *Reprinted from* Proc., Natl. acad. sci., Washington, Jan. 1916, 2: 24–27.

about a 10 per cent change in the intensity of solar radiation.

c. Since the changes in solar radiation are aperiodic and occur more or less spontaneously, the effect on the earth's magnetism is generally of a threefold character: (1) An alteration in the diurnal range, (2) perturbations both of the world-wide and the local kinds, (3) an outstanding residual effect such as to alter the daily mean values of the magnetic elements by an amount 10 to 100 times that caused by the regularly-progressing secular variation. The magnitude of the effects may at times exceed the average ones described in (*a*) and (*b*), dependent upon peculiar local conditions (ionizations) of the upper atmospheric layers. Changes in solar radiation may thus furnish sufficient cause for the ever-present minor perturbations and elementary waves or pulsations of the earth's magnetism.

d. The daily noncyclic changes in the earth's magnetism, as found on magnetically quiet days by previous investigators, furnish an additional check on the foregoing results, their quantities harmonizing completely both as regards sign and magnitude with those given here. It is found that on consecutive quiet days the magnetic constant is, on the average, larger on the second day than on the first, the increase being equal to that which would be caused by an average daily change in the solar constant. Moreover, the reason why the magnetic constant, or the horizontal intensity, is larger, on the average, on the second quiet day is because, on the average, the solar constant is slightly smaller on the second day than on the first. The relation between solar change and magnetic change during consecutive quiet days is precisely of the same sign and amount as given in (*b*).

e. If the quiet-day magnetic effect were to persist throughout the year, it would cause a secular variation fully ten times that generally observed. However, the quiet days are in the minority, being exceeded three times and more by unquiet days on which the magnetic effect is of an opposite or compensating kind to that of the quiet day. Since these acyclic effects appear to be associated with solar changes, and since the latter are not periodic, but more or less sporadic, there is an outstanding effect at the end of the year which causes an irregularity in the regularly-progressing secular change. Accordingly, there should be found some correspondence between annual changes of the solar constant and annual magnetic changes. This is found to be the case. Since the solar-constant changes occur only approximately in accordance with sun-spot activity and since the magnetic changes are found to conform so closely to those in the solar constant, an explanation is obtained as to why the irregularities in the magnetic secular change do not always synchronize with changes in solar activity as measured by the sun-spot numbers nor correspond in magnitude to them.

THE RADIOACTIVE DEPOSIT FROM THE ATMOSPHERE ON AN UNCHARGED WIRE.

By S. J. M. ALLEN.

[Dated: University of Cincinnati, June, 1915.]

[*Reprinted from* Physical Review, Lancaster, Pa., January, 1916 (2), 7:133-138.]

In the Physical Review for 1908 appeared an article by the author on the "Radioactivity of the Atmosphere," which stated that a considerable amount of active deposit could be obtained from a smoky atmosphere on an uncharged wire. This deposit was the same in nature as that obtained when the wire was charged to a high negative potential, having decay curves varying between the same wide limits.

Mr. Wilson, at Manchester, England, published a paper [1] in which he stated that he could get no appreciable deposit on an uncharged wire, though he got an effect when the wire was negatively charged. This seemed strange, as one would expect a considerable effect at Manchester, which by report is as smoky as Cincinnati. Granting that the conditions are favorable at Manchester for obtaining the active deposit, Mr. Wilson's negative result may be explained in several ways. With a wire of only 50 feet he could not expect to obtain enough deposit to measure unless he used a very sensitive apparatus. The active deposit on an uncharged wire is in general small compared with that on a charged wire. Careful correction or elimination of the "natural leak" of the apparatus would be necessary. The author used 360 feet of wire and a very sensitive balance method in which the natural leak was eliminated.

Mr. Harvey, at Denver, Colo., states [2] that he could obtain a very small effect on an uncharged wire in an atmosphere which was very clear as far as smoke was concerned but contained a considerable amount of dust.

There does not seem to be much doubt that in an atmosphere containing small nuclei, such as dust, smoke, rain, and snow, one can collect a radioactive deposit without the aid of a strong electrical field. These nuclei act only as carriers and are drawn to the wire by diffusion, or wind. It is probably true that in case of smoke and dust particles the nuclei are sometimes charged. Negative nuclei would therefore be the most efficient as collectors of the radioactive matter, which is positively charged. Any wire insulated in the air would be subject to the effect of the natural potential gradient of the atmosphere which is normally negative with respect to earth. Except in rare cases this potential gradient would not be comparable with the high ones usually used by experimenters in different parts of the world.

The author could get an active deposit whether the wire was insulated from, or connected to, the earth, and even a small trace when it was positively charged.

The present paper gives an account of further observations made during the last 14 months under different atmospheric conditions. They are of considerable local interest, since for several years the Smoke Abatement League has labored to decrease the amount of smoke, and in the last year or two has been quite successful; so much so that to-day the average clearness of the atmosphere at Cincinnati is greatly improved over what it was a few years ago. It was therefore of interest to see if this was having any effect on the active deposit.

The experiments were carried out in exactly the same place and with the same apparatus as those in 1908. The wire was 360 feet long, running as an endless belt over pulleys. The active deposit was rubbed off onto a piece of cotton, or linen, and tested in the null reading "balanced" electrometer devised by the author. The electrometer was made very sensitive, and an uranium oxide standard used. Before each reading the "natural leak" was exactly balanced in the testing chamber and the standard, so that the only ionization measured was that of the active deposit.

By several preliminary experiments the conclusion was reached that nearly all the active deposit was removed from the wire by rubbing. At any rate only the outer layers of the deposit would be very active, since in a

[1] *Wilson*, Phil. Mag., 1909. [2] *Harvey*, Phys. Rev., 1909.

24-hour exposure the first active layers would have decayed away by the time of removal.

Observations were made on most days that the weather would permit. Those during the summer months are rather incomplete, as the author was absent from the university during that time. Exposures varied from about 15 hours to several days. An exposure longer than one day did not seem to make much difference in the active deposit obtainable. On many days decay curves were taken over as long a range as possible.

The results obtained for the last 14 months are shown in Tables 1 and 2. Table 1 [omitted] gives the complete observations for the highest and lowest months; Table 2 the summary for each month. The activity is given in terms of uranium oxide. A reading of 100 is equal to that of 1 square centimeter of uranium oxide of about nine-tenths the thickness of the McCoy standard ($100 = 5.2 \times 10^{-13}$ amperes). A characteristic set of decay curves are also shown.

TABLE 2.—*Summary of measurements of radioactivity of deposits on a 150-foot wire at University of Cincinnati.*

[In terms of uranium oxide: $100 = 5.2 \times 10^{-13}$ amp.]

Month.	Activity.			Number of observations.	Periods of rain.
	Maximum.	Minimum.	Average.		
1914.					
March	375	47	149	9	3
April	300	48	163	20	4
May	520	50	183	23	4
June	391	120	232	9	2
July	308	36	132	5	2
September	268	125	191	5	1
October	500	68	196	23	10
November	580	48	316	19	3
December	414	50	193	13	9
1915.					
January	443	54	223	18	8
February	410	28	181	13	5
March	268	0	170	18	5
April	207	68	125	14	4
May	396	100	242	18	10
Mean			193		

The following summary will serve as a discussion of the results obtained:

1. It has been clearly shown that an active deposit can be obtained on an uncharged wire in a smoky atmosphere, such at exists at Cincinnati.

2. From the decay curves [figure omitted] it can be readily seen by careful examination that the active deposit consists of a mixture of the various disintegration products of radium. All the curves can be divided into three classes: Those which are at first convex upward followed by concave upward; those which are concave upward, then convex upward, and finally concave; and those which are very approximately exponential over their complete range. The periods (half decay values) vary from 8 to 50 minutes. A common exponential has a period of about 28 minutes (Radium C). Of course the deposit is a chance mixture, which accounts for the great variation in the decay curves. Deposits have been taken which differed by only a few hours, and which showed entirely different decay curves.

3. On no occasion could a decay curve be obtained which showed a period long enough to be taken for the thorium products. If it was present at any time it was never greater than the experimental error, certainly not greater than 10 per cent. This is in sharp contrast with the results shown in 1908 for a charged wire, when the thorium products were sometimes present in proportions as great as 30 to 40 per cent. It must therefore be that the thorium products are present in the air in small quantity compared with the radium products, or that they do not collect readily on smoke particles.

4. The amount of soot deposited varied through wide limits, the maximum amount collected in 24 hours being about 0.12 gram. It was found that in general a large amount of soot indicated a large amount of activity, although there were several cases where a large activity was obtained from a small deposit of soot. I think it can be safely said as a rough approximation that, if the radioactive matter in the atmosphere remains the same, the amount of activity on the wire is proportional to the amount of soot deposited. This, of course, would be only true for a steady state up to equilibrium. An interesting case was observed once. One day the activity was 90 with clear weather. During the night there occurred one of the heavy smoke fogs which used to be common to Cincinnati, but now more rare. In the morning the activity was 448. The next day was clear again and the activity dropped to 100. The normal activity was thus low, but the heavy precipitation of smoke deposited a large activity momentarily on the wire.

5. The activity does not seem to vary greatly in summer and winter, but the results so far obtained would seem to indicate maxima and minima periods. A maximum occurs around November and December and a minimum around April. A possible reason for this would be the following: At the approach of winter the production of smoke particles in the air is greatly increased, due to inefficient stoking and to the bad condition of the furnaces lying idle all summer. By late winter more efficient operation has been obtained, with the result of much less smoke. It is a fact that the amount of soot in the air here in early winter is much greater than in late winter. In November the deposit was very thick and black, while in April it was light and gray and mixed with dust. Both months were very fine. In May, though the weather was very wet, the activity was very much greater than in April. Whether actual maxima and minima occur in the amount of active matter in the air is not yet certain. Future observations over a long time may give results of interest.

6. Winds from northwest to southwest in general give the largest activity, while those from the east give the smallest. Winds from the former quarter in Cincinnati blow over the smoky part of the city and also bring fine weather. East winds come from over the residential parts.

7. The effect of rain is very certain. A heavy continued rain always clears the air of the activity. If the weather clears up with strong west winds, the activity rises rapidly to its normal value. Before a rain the activity decreases gradually. Even during a rainstorm one can often obtain a small amount of activity by rubbing the sooty water from the wire and then drying the cloth. On one or two occasions, even in fine weather, not enough active deposit to be measured could be obtained.

In conclusion, one can say that the results enumerated and discussed in this paper fall into line with the general results on the radioactivity of the atmosphere observed by different experimenters in many parts of the world, the deposit on an uncharged wire being due to the smoke nuclei in air acting as carriers. The actual deposit at any time is a chance diffusion mixture in all proportions and states of decay of the radium products present in the atmosphere.

PENETRATING RADIATION AT HIGH ALTITUDES.[1]

By W. KOLHÖRSTER.

[*Reprinted from* Science Abstracts, Sect. A, Dec. 28, 1915, §1691.]

A series of experiments on the determination of the penetrating radiation present in the earth's atmosphere, have been made at various known altitudes above the earth's surface. The instrument used in measuring the ionisation was the author's modification (Sci. Abs., 1914, §888) of the Wulf type of electrometer. The following interesting table of results is given:

Height above sea level.	Difference between the number of ions per cubic meter at the height considered and on the earth's surface.	
	1913	1914
Meters.		
1,000	−1.5	.....
2,000	1.2	.....
3,000	4.0	4.3
4,000	8.3	9.3
5,000	16.5	17.2
6,000	28.7	28.7
7,000	.....	44.2
8,000	.....	61.3
9,000	.....	80.4

Assuming the relation $I = I_0 e^{-\lambda d}$ for this radiation, the value of the absorption coefficient for air at atmospheric pressure is given as 1×10^{-5} cm.$^{-1}$, whereas that of the γ-radiation from Radium C is 4.5×10^{-5} cm.$^{-1}$. This radiation is therefore extremely hard, being only reduced in intensity by 1 per cent in a layer of air (at atmospheric pressure) 7 km. in thickness. It is shown in the above manner that a very penetrating radiation exists which has its origin somewhere in space, but by far the greater part is due to the sun.—*A. B. W[ood]*.

AURORÆ, EARTH CURRENTS, AND MAGNETIC DISTURBANCES.[2]

By OTTO KLOTZ.

[Dated: Dominion Observatory, Ottawa, Canada, Oct. 23, 1915.]

[Auroræ, earth currents, and magnetic disturbances] may all be treated as a common subject or phenomenon. Let it be stated right at the outset that our ignorance of them is still vast.

The following dispatch from Winnipeg on June 17, 1915, is so interesting that it is inserted in full, besides giving an opportunity for explaining some of the statements made therein:

Aurora, more mysterious than wireless telegraphy, less constant than the visible manifestations of electrical storms, is to-day tangling up all the telegraph wires strung across the top of the continent, more especially those along the north shore of Lake Superior. There has not been such a complete tie-up in the telegraph business between eastern and western Canada for a long time, and possibly records for the month of June might be searched for many years back without finding a parallel. In fact, well-conducted auroræ confine themselves to the fall and winter months, and of all the months in the year June is most immune. The record of observations in Scandinavia and Iceland, as well as the Spitzbergen station, show no aurora at all in June, though on the North American Continent it is not unknown, though still a rare June phenomenon.

Aurora manifestations are almost entirely confined to night, and these manifestations, whether visible or not, are commonly accompanied by magnetic earth currents, and it is these properly that affect the wires. Usually with the morning sun the whole manifestation lifts, wires surcharged with excessive and variating currents are freed and released for their daily business, and the atmosphere, overloaded with electricity, becomes normal. But to-day the magnetic storm, potent though both unseen and unheard, is raging as furiously, to the tune of crackling wires at noon, as it was at midnight. The sky is heavy and overcast. When the clouds lift and the sun breaks through, the whole trouble will vanish magically as it came. For generations scientists have sought the secret of aurora and earth currents but have learned little beyond the central fact of the inconstancy of all available data on the subject.

Another peculiarity of the present visitation—a scourge alike to the telegraph companies and the daily newspapers—is that, whereas usually it is only wires running east and west that are affected by the polar visitant, on this occasion wires running north and south, such as those between Winnipeg and Minneapolis, are affected to nearly the same extent. From the meteorological point of view, this magnetic storm adds one more to the queer performances of the current month of June.

The first and natural question to occur to an observer beholding the aurora—a brilliant aurora with its dancing, shooting streamers; building, forming, and dissolving; rushing from its northern arch to meet beyond the zenith; clothed, perhaps, in greenish gauzy drapery, or yet in portentious red; ceaseless activity, a mysterious phenomenon, bewildering to mind and brain—is: What is the aurora? Beholding it gives no answer, but when we compare the phenomenon with associated ones we learn a little of its nature. We find it to be electric in its nature, an electric discharge. But here our positive knowledge about its nature stops.

We may mention the theories that have been advanced to account for the aurora. Birkeland regards the phenomenon as due to cathode rays emanating from the sun; Nordmann replaces the cathode rays by Hertzian waves; and Arrhenius supposes negatively charged particles to be sent out by the sun and reaching the earth, ionizing the upper regions of the atmosphere and thereby making it a good conductor for electrical discharges. The cathode rays we know travel at about a tenth of the velocity of light, hence would take nearly an hour and a half to reach us from the sun; the Hertzian waves at the velocity of light, i. e., 186,000 miles a second; and Arrhenius's particles would take about 46 hours, about two days for transmission. The transmission time forms an important factor when an attempt is made to associate particular sun spots and solar outbursts with particular auroræ and magnetic disturbances. The solar effect is that the discharge of the difference of potential on the earth is greatly facilitated; we have an electric current established with its consequent phenomena of auroræ, earth currents and magnetic disturbances. These are all more or less influenced by local conditions on or in the crust of the earth, and hence vary in intensity at different places. However, the strong currents encircle the earth, as we see in some notable cases, and manifest themselves particularly in magnetic disturbances and earth currents.

The electrical discharges, for of such are the auroræ, where do they take place? Many measurements and photographs (Störmer) have been made of the aurora to determine its position—height—in our atmosphere, and it has been found that the height, although varying considerably, is of the order of 50 miles. At that elevation the atmospheric pressure is only about 1/500 of an inch, about the pressure in a Geissler tube. The discharge of electricity through highly rarified gases and vapors in the large tubes, with the accompanying glow, at the Centennial Exposition in 1876, impressed the writer at the time with its close analogy and resemblance to the aurora or northern lights.

We may look upon the sun, not as the source of the magnetic disturbances, but as the medium that sets loose the bound energy residing in and on the earth.

[1] Deutsch. Phys. Gesell., Verh., July 30, 1914, 16, 14:719-721.

[2] *Reprinted from* Jour. Roy. Astron. Soc. of Canada, January, 1916, v. 10, No. 1, p. 8-14.

It will generally—although not always—be found that the center of the auroral arch, if there be one, is in the magnetic meridian. In eastern Canada and the eastern United States this will be west of the true or astronomic north, while west of Lake Superior to the Pacific it will be east of the true meridian. Furthermore, if the streamers ascend from the north toward the zenith or beyond it, it will be found that their focus or meeting place is beyond or south of the zenith, and at a point approximately where the direction of the dipping needle intersects the celestial vault. We see here then a pretty close connection between the aurora and compass and dipping needle, which we know otherwise to exist. It is fairly safe to say that there is never a bright auroral display without an accompanying magnetic storm, and [in support] many cases might be cited. The inverse of the statement—that with every magnetic storm we have auroral display—is not so obvious, because the magnetic instruments are always at work, being self-registering, independent of day or night, while the aurora is a matter of visibility, and hence observations are [confined] practically to the night. Here we may cite a most interesting case—that of the great auroral display and great magnetic storm of June 17, [1915] last. Prof. E. E. Barnard, in Nature of July 15, [1915], gives a vivid description of the aurora as seen at the Yerkes Observatory.[3] The maximum brilliancy was reached shortly after 2 a. m., central standard time [90th mer. time], and shortly afterward dawn blotted out further observation. While the aurora was pursuing its magic performances in the heavens the magnetic instruments all over the world were mightily perturbed, and as we know from the Winnipeg dispatch quoted and other press reports, the telegraph lines were more or less demoralized by the atmospheric electric currents. While dawn was breaking with us, night was approaching in New Zealand, so that this world-encircling phenomenon could be observed there after daylight had made it invisible in America. And this is what happened. While it was midsummer with us, it was midwinter at Dunedin, latitude 46° S., longitude 170° 30′ E., or $11^h\ 22^m$ ahead of Greenwich, and the sun set before 5 p. m. Standard time in New Zealand is fast on central standard time $17^h\ 30^m$, so that 2 a. m. quoted by Barnard would be $19^h\ 30^m$ or 7:30 p. m. in New Zealand.

Mr. W. E. McAdam, of Dunedin, writes:

> Upon that day (June 17) there was an exceptionally fine display of the Aurora Australis visible all over New Zealand. Here, at Dunedin, it commenced at 7:30 p. m. and lasted till midnight. The glow in the southern horizon was quite uncanny in effect, producing the illusion that the sun was about to rise in an impossible quarter of the sky, and at an impossible hour. I have been resident in the Southern Hemisphere off and on for 50 years, and have never seen anything to equal the last display of the Aurora Australis, a somewhat rare phenomenon, in the latitude of Dunedin, 46° S.—(Nature, Sept. 30, 1915.)

This is a most interesting case, showing that while the "movies" became invisible in Canada, the night of New Zealand revealed their continued presence.

The aurora does not distribute its favors equally over the earth. The Tropics and semi-Tropics are practically devoid of them. The curves of equal frequency dip considerably farther south in America than in Europe. No country is so favored by this ethereal visitant as is Canada. From what has been said it is obvious that more auroræ will be seen and are seen during the winter months than during those of summer, simply because in the former case the nights are longer and consequently [increase our chances of seeing] the aurora, if there is one.

The aurora has often the appearance of filaments or streaks of clouds, but the distinction is readily observed by the presence of a star or stars behind; for the transparency of the former dims but little, if any, the brightness of the star, which by the latter, even if filmy, would be more or less obliterated.

In tabulating sun spots and the frequency of auroræ over a long period of years, it is found that there is a very general agreement between the maxima of the one and the maxima of the other, and similarly between the minima, but the definite relationship between the two is not known. Auroræ, magnetic disturbances and earth currents are simultaneous phenomena due to electric currents in the higher regions of the atmosphere. Their individual intensity is to a degree dependent on local conditions, such as difference in geological formations, and all follow in a general way the sun-spot cycle of 11 years.

In examining the spectrum of the aurora it is found that there is one rather prominent line in the yellow-green, wave-length 5571μ, which coincides with a prominent line in the sprectrum of krypton.

The writer has seen many auroræ in our Northwest, their home, and has conversed with Hudson Bay Co. officers and voyageurs from whom information is said to have been obtained that noises have been heard during auroral displays, and [whose statements have] been quoted in books and articles on the subject; yet the writer is convinced that there is no authentic record of any noise ever having been heard, although subjectively the "noises" may have been *felt*, as was the case, I am sure, with Ogilvie's man.[4]

The interference of earth currents with the working of telegraph and cable lines is largely overcome by making a metallic circuit and, thereby, cutting out the earth. This, of course, reduces the capacity of the service.

Prof. Barnard reports that signals on June 17, during the aurora display, on the wireless receiver at the observatory were not affected, and that the static conditions were normal.

With reference to earth currents and cables, the writer may be permitted to quote extracts from his official report in 1892, in connection with the trans-Atlantic determination of longitude. At that time there were 10 cables across the Atlantic, but when earth currents set in they were not all equally disturbed, in fact, sometimes some of the cables not at all.

> The French cable from Brest to St. Pierre seems to be disturbed the most, and again the disturbances are felt to a greater extent at St. Pierre than at Brest. It often happens that St. Pierre can send messages to Brest but can not receive any. Long cables seem to be more affected than short ones, and, furthermore, the earth currents appear to travel mostly from east to west. When the aurora is visible it is pretty certain that earth currents will show themselves. Thunderstorms and [earth currents?] however, do not seem to be so closely related, if at all. During the past season (1892), on July 16, there was a remarkable disturbance noticed at Canso, stopping all work completely. The greatest "kick," as it is called, was given at 12:20 p. m., E. S. T., or 5:20 G. M. T. Some weeks afterward reports came in the technical journals, from Brest, Malta, Cairo, Madras, and east to Singapore, of a similar disturbance on that day. Cairo, Egypt, fortunately stated the time, and from it it was found to have been simultaneous with that of Canso. On August 24 (1892) strong earth currents set in at Canso, and at the time there was a marked auroral display. The southern cable (Commerical Co.) was far more affected than the northern one. As most of the companies have two cables they can generally get rid of the effects of earth currents by looping the cables together—that is, by making a metallic circuit. Sometimes the earth currents are so strong as to injure the condensers. From the direction of the cables it is noticed that cables running east and west are more troubled with these currents than cables running north and south. There is, however, a wide difference on east and west lines. The superintendent at St. Pierre told me

[3] See also this REVIEW, November, 1915, p. 546; September, 1915, p. 445.—C. A. jr.

[4] *See* J. Oxall in this REVIEW, Jan., 1914, **42**: 27-29.

that he experienced more earth currents in the past 2 years (1891, 1892) at that place than in the preceding 18 years at Torbay and Canso, N. S., and beside that they are felt more on the American than on the European side. And furthermore:

"The cable is quite unprejudiced and shows equal favor to positive or negative gallantries. They are of the most erratic nature; sometimes they take off their things and make quite a visit, 1, 2, or 3 days, varying greatly in their demonstrativeness during the time, but seldom getting so bad as to totally stop traffic. Sometimes they favor us with a 2 or 3 minute call only, as if to remind us that they are still alive. They fluctuate in degree very greatly. The strength or electromotive force of these earth currents has run up to 500 volts."

We have now said considerable about the subject of this paper, yet have, undoubtedly, failed to answer all the questions of the "practical" man. The practical man wants the aurora, earth currents, and magnetic disturbances stopped, for they interfere with his work; the scientist doesn't want them stopped for they are a stepping stone leading upward toward unraveling the grand mechanism of nature. All life, all activity, all energy of the earth we may trace back to the sun, and until his secrets are revealed we shall remain in ignorance of much that is going on on our globe. At present our hopes are specially centered on Mount Wilson, where Prof. Hale and his assistants are bending all their energies upon our central orb. They intercept every messenger coming from the sun and put him through a rigorous examination—what his business is and what dispatches were intrusted to him before he left home. All these dispatches are written in hieroglyphs, and only for a few, as yet, has a Rosetta stone been found for their interpretation. No gained ground is ever lost by the scientist; he is ever on the offensive. Of the messengers sent out by the sun, the earth intercepts but a very small portion; less than one two-thousand-millionth.

Until some of these messengers have been made to reveal their secrets we can only conjecture as to the why of the aurora, earth currents, and magnetic disturbances.

SECTION II.—GENERAL METEOROLOGY.

THE MELTING OF SNOW.

By ROBERT E. HORTON, M. Am. Soc. C. E.

[Dated: 57 North Pine Avenue, Albany, N. Y., Jan. 14, 1916.]

It is a familiar fact that if there is deep snow on the ground streams do not rise as rapidly after a rain as they would if the ground were bare. On the other hand, when there is a fall of light snow followed by a warm heavy rain which removes the snow the intensities of resulting floods are sometimes greatly augmented. In general, there is a marked lag between the melting of snow and the appearance of the resulting water as run-off in the streams.

As an aid to a better understanding of the relation of snow accumulation to the flow of streams and to floods, the writer undertook a number of simple experiments.

Several cylinders with open ends were filled with snow, the average depth being 5½ inches. The cylinders were each 2.45 inches in diameter and they were placed on end in air at a temperature of from 30° to 32°F. The snow in the cylinders had an average density of 0.333. Water at temperature 48° was poured on the snow in the cylinders in varying depths from 0.16 inch to 1.46 inches. The cylinders stood in tin dishes intended to catch any percolation through the snow which might take place. In no case was there any percolation whatever through the snow after the cylinders had stood for one hour's time in this test. On removing the cylinders from the prisms of snow it was found that the water added had all percolated to the bottom of the prism and was held in a capillary column of a height proportional to the quantity of water added. It was necessary, therefore, to make a further test in order to determine the height to which water would be held in capillary suspension in the bottom of a column of snow before any percolation would take place. By adding increased quantities of water it was found that for the new sample, having density of 0.448, a capillary column 2 inches in height was supported by the snow. This was equivalent to a depth of 1.1 inches of water. It was found, however, that 1.57 inches of the water added to the snow remained therein, indicating that part of the water added remained in the unsaturated prism of snow above the capillary column. From these and other experiments described hereafter it appears that snow under suitable conditions behaves like any other permeable medium, such as a porous soil, as regards the percolation of water through it and its capillary retention in the interstices of the medium. In the experiments above described the snow prisms were placed on a solid surface. If the snow prism was placed on a capillary surface, such for example as a mass of blotting paper or a layer of moist nonsaturated soil, then the capillary lifting power of the snow column would be balanced not by gravity alone but by gravity plus the capillary downward pull of the underlying medium, and a portion of the capillary water held in the snow column would be removed.

During the past three winters there have been unusually heavy falls of snow at Albany, and on each such occasion the writer has kept a record of the progressive decrease in depth and increase in density of snow on the ground, and has performed various experiments to determine the rate of melting of the snow and the disposition of the water produced thereby. These experiments were performed in a yard nearly level but with a very slight slope toward the center from all sides, so that no surface run-off takes place. The soil is a fine-textured uniform sand into which water percolates very readily. Experiments show that water will percolate into this material even when the ground is frozen as hard as brick, owing apparently to the fact that the soil surface is never fully saturated at the time when it freezes.

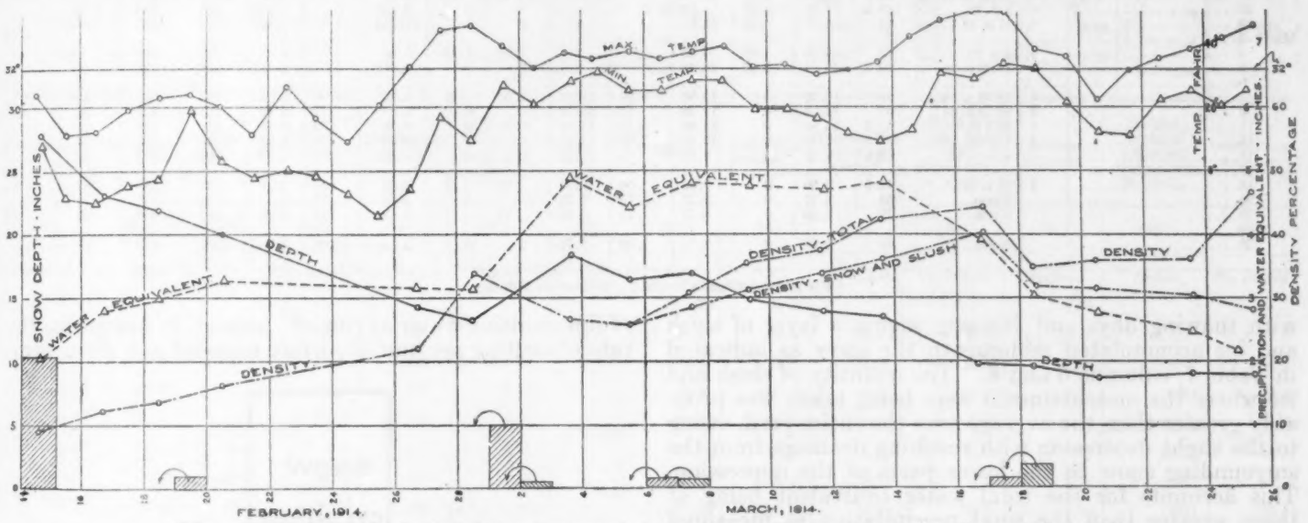

FIG. 1.—Progressive change in depth, density, and water equivalent of snow accumulation, Albany, N. Y., February-March, 1914.

The accompanying Table 1 presents the results of snow-density tests during February and March, 1914. This series of tests began immediately after a very heavy fall of snow. The depth in the writer's yard was 27.75 inches, as determined from a mean of four samples taken in a galvanized raingage can. The water equivalent was 2.04 inches. This was somewhat greater than the recorded catch at the U. S. Weather Bureau station about 2½ miles distant. Owing to the local surroundings, it appears that the depth of snow which fell at this immediate locality was considerably greater than that which fell in other parts of the city more exposed to the wind. There was little drifting of the snow in the writer's yard.

The results of this series of observations are shown graphically in figure 1, from which it appears that the

temperature was uniformly below freezing for six days after the heavy fall of snow. There was but little wind, the snow did not drift but the depth decreased uniformly and the water equivalent and density increased quite uniformly. Similar progressive decrease in depth and increase in density prevailed except when the depth was augmented and the density reduced by additional falls of snow, until the entire snow cover had disappeared. From February 26 on, the temperature generally rose above freezing during the daytime, and during the period

TABLE 1.—*Snow density tests, Albany, N. Y., February–March, 1914.*

Date.	No. tests.	Time.	Interval.	Depth of snow, etc., on ground.					New snow.		Water equivalent.			Ratio.		Water loss.	Precipitation.[1]
				Snow.	Slush.	Snow and sleet.	Ice.	Total.	Depth.	Water.	Snow and slush.	Ice.	Total.	Snow and slush.	Total.		
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)
1914.			*Hours.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*			*Inches.*	*Inches.*
Feb. 14	2	5 p. m.	0	27.75	0	27.75	0	.....	0	0	2.04	0	2.04	0.0918	0.0918	.....	.....
16	4	8 a. m.	39	23	0	23.00	0	.....	0	0	2.80	0	2.80	.123	.123	—0.76	0.02
17																	.01
18	3	12 m.	52	21.8	0	21.80	0	.....	0.75	0.06	2.98	0	2.98	.136	.136	— .18	.....
19																	.20
20	4	12:30 p. m.	48.5	20.0	0	20.00	0	.....	2.75	.137	3.29	0	3.29	.164	.164	— .31	.....
26	4	3 p. m.	146.5	14.06	0.25	14.31	0	.....	0	0	3.142	0	3.142	.220	.220	— .148	.....
28	4	11 a. m.	44	12.77	.28	13.05	0	.....	0	0	3.146	0	3.146	.340	.340	— .004	.....
Mar. 1–2																	1.10
3	4	4 p. m.	77	17.59	.81	18.40	0	.....	6.00	1.10	4.86	0	4.86	.265	.265	— .714	.....
5	4	11:30 a. m.	43.5	15.34	1.06	16.40	0	.....	0	0	4.411	0	4.411	.256	.256	.449	.....
6																	.16
7	4	11:30 a. m.	48	16.90	0	16.90	0.50	17.40	2.50	.27	4.80	0.50	5.30	.284	.304	— .389	.11
9	4	10:30 a. m.	47	14.70	0	14.75	.75	15.50	0	0	4.74	.75	5.49	.311	.354	.06	.....
11	4	4:10 p. m.	53.7	13.80	0	13.80	.75	14.62	0	0	4.70	.75	5.45	.338	.372	.04	.....
13	4	4 p. m.	47.8	13.45	0	13.45	.75	14.20	0	0	4.84	.75	5.99	.360	.421	— .14	.....
16	4	4:30 p. m.	72.5	9.75	0	9.75	.75	10.50	0	0	3.92	.75	4.67	.401	.444	.92	.....
17																	.12
18	4	10 a. m.	41.5	9.60	0	9.60	.50	10.11	.25	.46	3.05	.50	3.53	.318	.348	.87	.34
20	.....	Noon.	50	8.77	0	8.77	.75	9.52	0	0	2.74	.75	3.49	.312	.366	.31	.....
23	.....	Noon.	72	8.25	0	8.77	.75	9.00	.04	.....	2.48	.75	3.23	.301	.360	.26	.02
24																	.01
25	.....	Noon.	48	5.70	0	8.77	1.00	6.70	0	0	2.15	1.00	3.15	.380	.472	.33	.....

[1] For precipitation 24 hours, U. S. Weather Bureau.

with thawing days and freezing nights a layer of slush and ice accumulated underneath the snow as indicated in Table 1, columns 6 and 8. The quantity of slush and ice where the measurements were being taken was probably greater than the average over the entire yard, owing to the slight depression with resulting drainage from the surrounding snow to the lower parts of the depression. This accounts for the total water equivalent being at times greater than the total precipitation as measured by the U. S. Weather Bureau station.

After March 14 the total water equivalent dropped off rapidly, the loss of water being partly due to evaporation, but more largely due, the writer believes, to infiltration in the frozen ground underneath the snow.

Each of the snow densities given in Table 1 is the mean of four tests from samples taken in different parts of the yard, the samples being taken with an inverted iron raingage cylinder and the density determined by weighing. These experiments confirm the earlier conclusions of the writer that an undisturbed layer of snow having an initial density of about 0.10 will increase in the course of the winter to an average density of 0.30 to 0.40. When, however, the layer of slush and ice at the bottom of the snow is taken into account, the density may become much greater, being oftentimes nearly unity when the snow has become reduced by successive thawings and freezings to a nearly solid mass of ice.

On February 20 and again on March 18, 1914, laboratory tests were made to determine the rate of disappearance of a prism of snow under constant temperature conditions. The results of the test of February 20 are shown in Table 2 and those of March 18 in Table 3. In each of these tests a prism of snow was carefully cut out with the galvanized-iron cylinder of the raingage and was set undisturbed upon a perforated pan to permit drainage, the drainage being caught and weighed in a can underneath. The draining and weighing apparatus used is shown in figure 2. The successive forms of the prism as melting progressed in the two tests are shown in figures 3 and 4, respectively. The object of these experiments was to determine, first, the amount of lag in time between a partial melting of the snow and the appearance of the resulting water as run-off; second, to determine the rate of melting per unit of surface exposed at a given temperature. Owing to the fact that the snow prisms became very irregular in form as melting proceeded and

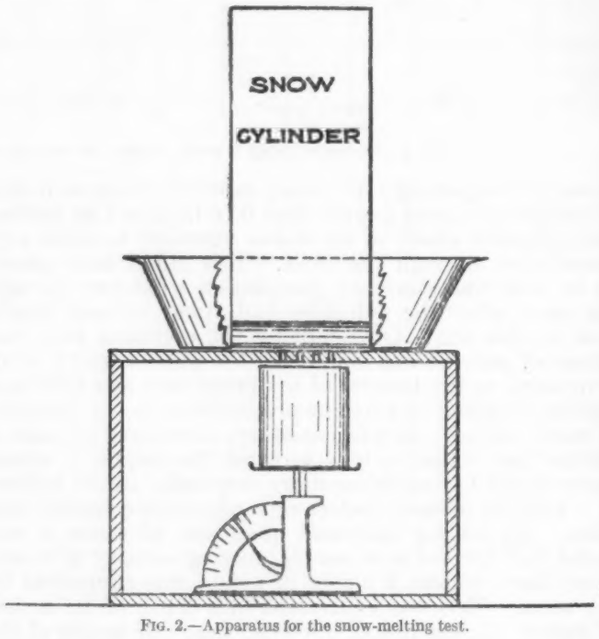

FIG. 2.—Apparatus for the snow-melting test.

further owing to the great difficulty of determining accurately the height of the capillary column of water retained at the base of the prism, the results given in Table 2, column **28**, and in Table 3, column **25**, can only be utilized for the purpose of determining the rate of melting during the earlier stages of the experiments From these figures it appears that each degree of temperature above 32° is able to melt a depth of snow equivalent to from 0.04 to 0.06 inch of water per 24 hours.

TABLE 2.—*Experiments on snow melting, Albany, N. Y., February 20, 1914.*

Hour.	Height.	Mean diameter.	Perimeter.	Cylindrical surface.	End area.	Total surface.	Mean surface.	Diameter base.	Area base.	Capillary rise.	Storage volume.	Net water, $\frac{1}{16}$ cubic inch.	Gain or loss of storage.	Total drainage. [1]
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
P. M.	*Inches.*	*Inches.*	*Inches.*	*Sq. inches.*	*Sq. inches.*	*Sq. inches.*	*Sq. inches.*	*Inches.*	*Inches.*	*Inches.*	*Cu. inches.*		*Cu. inches.*	*Ounces.*
12:48	20.00	8.0	25.13	502.6	50.26	552.9		8.0	50.26	0	0	0	0	0
							537.2						0	
1:00	19.80	7.65	24.02	475.6	45.96	521.6		8.0	50.26	0	0	0		0
							500.2						+ 9.6	
1:30	19.00	7.32	22.99	436.8	42.08	478.8		7.8	47.78	0.25	11.94	9.6		0
							444.9						+25.0	
2:00	17.70	6.75	21.20	375.2	35.78	411.0		7.7	45.57	.95	43.29	34.6		0
							394.4						+ 1.6	
2:30	16.60	6.60	20.73	343.6	34.21	377.8		7.4	43.00	1.05	45.15	36.2		12.0
							352.3						− 3.6	
3:00	15.50	6.10	19.16	297.6	29.22	326.8		7.2	40.72	1.00	40.72	32.6		24.
							308.6						− 7.77	
3:30	14.80	5.70	17.91	264.9	25.52	290.4		6.9	37.39	.83	31.04	24.83		34.
							250.9						−12.73	
4:30	12.50	4.90	15.40	192.5	18.86	211.4		6.2	30.20	.50	15.10	12.1		49.
							195.2						+ 2.1	
5:40	11.00	4.70	14.76	162.3	17.35	179.0		5.5	23.76	.75	17.82	14.2		65.
							156.7						− 4.76	
6:30	9.00	4.25	13.35	120.2	14.19	134.4		5.0	19.63	.60	11.78	9.44		[2] 78.
							96.1						− 6.35	
8:47	6.00	2.75	8.64	51.8	5.93	57.8		3.5	9.65	.40	3.86	3.09		94.
							28.9						− 3.09	

Drainage.	Drainage.	Time, days ÷ 1.	Total melting.	Melting per 24 hours.	Melting, depth of water per 24 hours.	Temperature.	Mean.	Difference from 32°.	Melting, per degree per 24 hours.	Melting per square-foot per degree per 24 hours.	Surface exposed.	Melting, depth of water per degree per 24 hours.	Cumulated melting.
(16)	(17)	(18)	(19)	(20)	(21)	(22)	(23)	(24)	(25)	(26)	(27)	(28)	(29)
Ounces.	*Cu. inches.*		*Cu. inches.*	*Cu. inches.*	*Inches.*	°*F.*	°*F.*	°*F.*	*Cu. inches.*	*Cu. inches.*	*Sq. feet.*	*Inches.*	*Cu. inches*
						76.0					3.73		
0	0					75.5	75.75	43.75					
0	0	48.0	9.6	460.8		73.5	74.5	42.5	10.8	3.11	3.47	0.021	9.6
0	0	48.0	25.0	1,200	2.70	73.5	73.5	41.5	28.9	9.32	3.10	.0647	34.6
12.0	20.76	48.0	22.36	1,075	2.73	73.0	73.25	41.25	26.1	9.53	2.74	.0661	56.96
12.5	21.62	48.0	18.02	864	2.46	72.0	72.5	40.5	21.3	8.70	2.45	.0604	74.98
10.0	17.30	48.0	9.53	457	1.48	71.0	71.5	39.5	11.6	5.42	2.14	.0376	84.51
15.0	25.95	24.0	13.22	317	1.26	69.5	70.25	38.25	8.31	4.78	1.74	.0332	97.72
15.5	26.81	20.5	28.81	590	3.03	69.0	69.25	37.25	15.9	11.7	1.36	.0811	126.54
13.0	22.49	28.8	17.73	510	3.25	70.0	69.5	37.5	13.6	12.5	1.09	.0867	144.27
16.5	28.54	10.43	22.19	231	2.40	71.2	70.6	38.6	5.98	8.97	0.67	.0622	166.46
			166.46										

[1] Original weight, 97.44 ounces.

[2] Overflow estimated at 10 ounces, probably more.

TABLE 3.—*Snow-melting tests at Albany, N. Y., second series, March 18, 1914.*

Time.	Height of prism.	Base.		Top.		Prism.			Total prism.	Capillary rise.	Storage volume.	Net storage.	Gain or loss.	Drainage.	Total melting.	Time interval.	Melting per 24 hours.	Total area.	Total area.	Melting per square foot in 24 hours.	Melting per square foot in 24 hours.	Temperature.	Excess over 32°.	Melting per square foot per degree in 24 hours.
		Mean diameter.	Area.	Mean diameter.	Area.	Mean diameter.	Area.	Perimeter.																
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)	(22)	(23)	(24)	(25)
	In.	*In.*	*Sq. in.*	*In.*	*Sq. in.*	*In.*	*Sq. in.*	*In.*	*Cu. in.*	*In.*		*Cu. in.*	*Cu. in.*	*Cu. in.*	*Cu. in.*	*Hrs.*	*Cu. in.*	*Sq. in.*	*Sq. ft.*	*Cu. in.*	*In.*	*°F.*	*°F.*	*In.*
9:40 a. m.	9.30	7.80	47.78	7.80	47.78	7.8	47.78	24.50	372.8	0	0					0		275.6	1.908			74	42	
10:00	9.10	7.60	45.36	7.60	45.36	7.6	45.36	23.86	345.0	0.50	22.18	14.30	+14.30	0	14.30	½	1,030.0	262.9	1.825	564	3.94	74	42	0.0938
10:15		7.50	Drainage starting.																					
10:20	8.90	7.60	45.36	7.50	44.18	7.55	44.77	23.71	340.4	.75	34.5	22.25	7.95	1.73	9.68	½	607.0	255.1	1.770	394	2.73	71	39	.0700
10:40	8.70	7.54	44.65	7.35	42.43	7.44	43.47	23.37	328.0	.75	33.5	21.61	− .65	6.92	6.27	½	451.4	246.0	1.707	264	1.83	71	39	.0469
11:00	8.50	7.53	44.53	7.34	42.31	7.44	43.47	23.37	327.5	.70	31.2	20.12	− 1.49	12.11	10.62	½	764.6	241.2	1.672	458	3.18	71	39	.0816
11:20	8.40	7.50	44.18	7.33	42.20	7.42	43.24	23.31	324.0	.65	28.7	18.51	− 1.61	6.92	5.31	½	382.3	237.9	1.652	232	1.61	72	40	.0402
11:40	8.00	7.18	40.49	7.22	40.94	7.20	40.72	22.61	292.2	.65	26.3	16.96	− 1.55	8.65	7.10	½	511.2	221.7	1.541	332	2.30	72	40	.0575
12 m.	8.00	7.10	39.59	7.15	40.15	7.12	39.81	22.36	282.5	.60	23.8	15.35	− 1.61	6.92	5.31	½	382.3	219.4	1.520	251	1.74	73	41	.0425
12:20 p. m.	7.85	6.90	37.39	6.55	33.70	6.73	35.57	21.14	245.6	.50	18.7	12.06	− 3.29	8.65	5.36	½	385.9	199.3	1.381	279	1.94	73.5	41.5	.0467
12:40	7.50	6.90	37.39	6.35	31.67	6.62	34.42	20.79	237.3	.50	18.7	12.06	0	12.11	12.11	½	871.9	187.7	1.304	671	4.65	74	42	.1110
1:00	7.20	6.60	34.21	6.05	28.75	6.32	31.37	19.85	207.2	.50	17.1	11.02	− 1.04	6.92	5.88	½	423.4	171.3	1.186	356	2.47	74.5	42.5	.0581
1:20	7.00	6.45	32.57	5.95	27.80	6.20	30.19	19.47	194.8	.50	16.3	10.51	− 0.51	6.92	6.41	½	461.5	163.6	1.138	406	2.82	75	43	.0656
1:40	6.90	6.35	31.67	5.85	26.87	6.10	29.22	19.16	185.4	.40	12.7	8.19	− 2.32	6.92	4.60	½	331.2	159.3	1.103	301	2.09	75	43	.0486
2:00	6.70	6.32	31.37	5.82	26.60	6.07	28.93	19.07	182.6	.50	15.7	10.12	+ 1.93	6.92	8.85	½	637.2	154.5	1.075	590	4.09	75	43	.0951
2:20	6.70	6.20	30.19	5.65	25.07	5.92	27.52	18.59	170.5	.50	15.1	9.73	− 0.39	6.92	6.53	½	470.2	149.7	1.041	451	3.13	74	42	.0745
2:40	6.50	6.05	28.74	5.40	22.90	5.78	26.24	18.15	158.5	.30	8.61	5.55	− 4.18	8.65	4.47	½	321.8	141.2	0.978	329	2.28	77	45	.0507
3:00	6.20	5.90	27.34	5.20	21.23	5.55	24.19	17.43	142.7	.35	9.55	6.16	+ 0.61	6.92	7.53	½	543.0	129.0	.895	607	4.21	76	44	.0957
3:20	5.80	5.75	25.97	4.95	19.24	5.35	22.48	16.80	129.3	.40	10.36	6.70	+ 0.54	8.65	9.19	½	661.2	116.0	.805	821	5.70	75	43	.0133
3:40	5.40	5.35	22.48	4.86	18.55	5.11	20.50	16.05	109.6	.30	6.75	4.35	− 2.35	5.19	2.84	½	204.5	104.9	.728	281	1.95	73	41	.0476
4:00	5.38	5.28	21.89	4.82	18.25	5.09	20.35	15.99	107.0	.40	8.76	5.65	+ 1.30	3.46	4.76	½	342.7	104.2	.721	475	3.30	75	43	.0768
4:20	4.50	5.05	20.02	4.52	16.05	4.75	17.72	14.92	89.3	.40	8.01	5.17	− 0.48	10.38	9.90	½	712.8	83.1	.577	1,235	8.57	74	42	.204
4:40	4.00	4.85	18.47	4.40	15.20	4.67	17.13	14.67	82.9	.30	5.52	3.56	− 1.61	5.19	3.58	½	257.8	74.2	.515	501	3.48	75	43	.0809
5:00	3.90	4.40	15.20	4.05	12.88	4.22	13.99	13.25	61.6	.30	4.56	2.94	− 0.62	8.65	8.03	½	578.2	63.9	.443	1,308	9.09	75	43	.211
5:20	3.80	4.10	13.20	3.85	11.64	3.97	12.38	12.47	50.8	.40	5.28	3.40	+ 0.46	5.19	5.65	½	406.8	59.6	.414	983	6.82	75	43	.159
5:40	3.20	3.60	10.18	3.45	9.34	3.52	9.73	11.05	35.0	.30	3.06	1.97	− 1.43	5.19	3.76	½	270.7	44.3	.307	882	6.12	76	44	.139
6:00																								
6:20																								
6:40	2.10	2.27	4.05	2.25	3.98	2.26	4.01	7.10	9.1	.40	1.62	1.04	− 0.93	3.46	2.53	½	182.2	18.9	.131	1,390	9.64	74	42	.230
7:00	1.80	1.95	2.98	1.88	2.78	1.91	2.86	6.00	5.57	.30	.894	0.58	− 0.46	3.46	3.00	½	216.0	13.6	.094	2,300	15.96	75	43	.371
7:20	1.20	1.25	1.23	1.28	1.29	1.26	1.25	3.95	1.56	.20	.246	.16	− 0.42	3.46	3.04	½	218.9	6.0	.041	5,341	37.06	75	43	.859
7:40	0.80	1.15	1.04	1.10	0.95	1.12	0.99	3.11	1.13	.20	.208	.13	− 0.03	0.865	0.84	½	60.5	3.43	.023	2,630	18.25	74	42	.434
8:00	.30	0.50	0.196	0.45	0.159	0.48	0.18	0.565	0.09															
8:05	0			0		0	0																	

In figure 5 an effort has been made to determine the relation between the total amount of melting expressed as a depth of water in inches, and the amount of percolation taking place from a snow prism. The line marked "total melting, cubic inches," figure 5, has been obtained by adding together the percolation and the quantity of water accumulated or stored in the base of the snow column in the form of slush. Later experiments on the percolation of water through snow indicate,

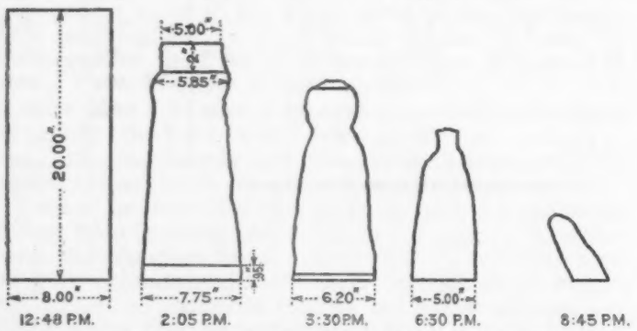

FIG. 3.—Snow prism during melting, Feb. 20, 1914. Experiment started at 12:48 p. m.; drainage started at 2:05 p. m.

however, that this line does not represent the total amount of melting. Melting takes place at the surface and the resulting water percolates downward through the prism of snow, part of the water remaining in the portion of the prism above the saturated column as a capillary film. The experiment does, however, illustrate strikingly the lag in time between the melting and the appearance of run-off, since in the experiments illustrated in figure 5 two hours elapsed after melting began before any percolation took place. In the meantime snow equivalent to something more than 34 cubic inches of water had been melted.

As the total weight of percolation finally obtained from the melting of the prism was but slightly less than the weight of the original volume of water contained in the experimental prism, it appears that the loss from surface evaporation during these tests was comparatively slight. The more rapid melting of the less dense, newly fallen snow lying on the surface is clearly illustrated by figure 3.

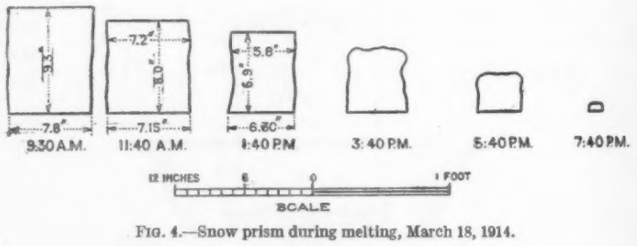

FIG. 4.—Snow prism during melting, March 18, 1914.

It was noted in the experiments that the height of the capillary column at the base of the prism gradually increased to a maximum before percolation began.

After percolation began the process seemed to be very irregular, the water flushing out at times rapidly, then again there would be but little percolation for a time. Some of the snow crystals were apparently melted by the percolating water so that the porosity of the base of the column was increased and its capillary power decreased, thus the height of the capillary column decreased as the melting of the prism progressed.

TABLE 4.—*Snow density tests, Albany, N. Y., December, 1915–January, 1916.*

Date.	Total depth.	New snow.	Slush or ice bottom.	Total water equivalent.	Ratio.	Precipitation, U. S. Weather Bureau, Albany, N. Y.	Total supply.	Gain or loss.	Maximum temperature.	Minimum temperature.
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
	Inches.	*Inches.*	*Inches.*	*Inches.*		*Inches.*	*Inches.*	*Inches.*	°*F.*	°*F.*
Dec. 13						1.98S.			32	18
14						0.35S.			32	23
15	29.82	29.75	0	3.465	0.116		3.465	+3.465	27	19
16									30	16
17	23.50	0	0.755	3.345	.141	0.23R.	3.70	−0.36	38	13
18	18.50	0	0.505	3.486	.189	1.12R.	4.82	−1.32	39	36
19									37	30
20	14.50	0	0	3.486	.241				34	23
21									32	22
22	14.50	0	0	3.423	.236				32	15
23						0.05R.	4.87		39	31
24	11.00	0	0	2.961	.269				42	35
25						0.01R.	4.88		45	34
26						1.84R. and S.	6.72		46	23
27									35	26
28	10.75	0	0		.214	0.035	6.75		38	32
29						0.625	7.37		32	22
30	18.50	7.00	0		.234				22	8
31									20	2
Jan. 1										
2										
3	16.50	0	0		.298					

A fall of 29¾ inches of snow occurred at Albany December 13–14, 1915. The results of density tests of this snow layer and of subsequent falls of snow are shown in Table 4. At the time this snow fell the ground was not saturated and was but little frozen. Snow temperature

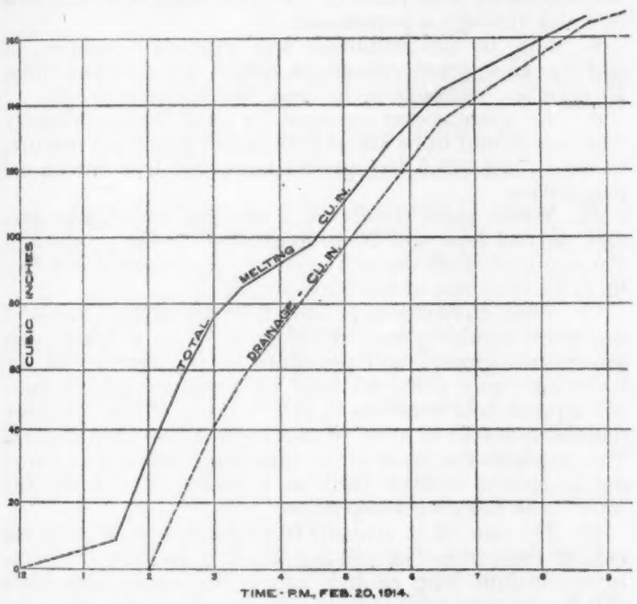

FIG. 5.—Illustrating time lag in run-off from melting snow. (Experiment of Feb. 20, 1914.)

gradients have been taken in this snow as shown on figure 6. The temperature at the ground surface remained nearly constant from December 15, 1915, to January 1, 1916, at 30° to 32°. The temperature within the mass of snow gradually decreased from the bottom to the surface as long as the temperature was low. On January 1, 1916, with an air temperature of 30°, the minimum temperature of the preceding day having been −2°F., there was a sharp inversion of temperature 5 inches below the surface in the snow layer.

On December 25, 1915, an experiment was made to determine the maximum rate of percolation through a prism of this snow, treating it as a porous medium. For this purpose a prism of snow of 4.71 square inches cross section was used, its temperature being about 30° and its average density 0.64, the snow being packed into the tube as uniformly as possible. The depth of the prism was 21 inches. When the surface of this prism of snow was kept covered with water at 32°, the water flowed through the snow prism by percolation at a velocity corresponding to a depth of 2.28 inches (0.19 foot) on the surface per minute. This may be taken to represent the transmission constant analogous to the transmission constant for flow of ground-water for snow having a porosity of 36 per cent and at the given temperature.

Where snow lying on the ground contains a saturated layer or layer of slush at the bottom, the water will tend to flow along the ground surface from higher to lower levels apparently in accordance with the ordinary laws governing the flow of ground-waters. Using the transmission constant determined as above for snow of the given density and taking the height of the capillary column as D, the rate of horizontal flow of water along the ground surface would be

$$q = 0.19SD,$$

where q = the quantity of flow in cubic feet per minute per foot of width, measured at right angles to the direction of slope; S = slope of the ground surface.

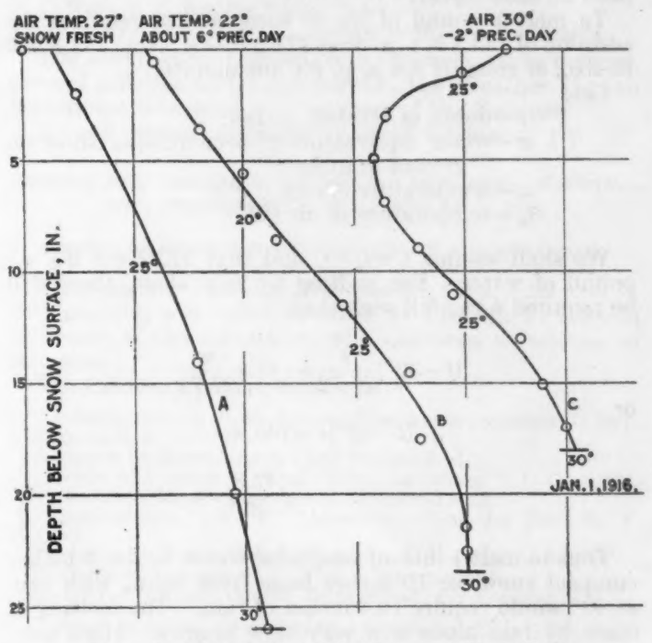

FIG. 6.—Vertical temperature gradients in snow, at Albany, N. Y.

Under the conditions given, with a ground-surface slope of 1 in 50 or 100 feet per mile, and with a depth of slush of 0.10 foot, the rate of flow through a layer of slush would be 1.6 cubic feet per day per linear foot. This is equivalent to about 0.1 cubic foot per second per mile and illustrates the extremely slow rate at which a stream may be fed from the melting of snow where the water must flow through the layer of snow itself.

Since the transmission constant for a porous medium increases much more rapidly than the porosity, it is probable that the rate of flow through snow of the ordi-

nary densities—say 0.30 to 0.40—of an accumulated snow layer would be four or five times as great as through the sample tested, and freshly fallen snow of density about 0.10 offers comparatively little resistance to the flow of water over the surface of the ground. Further experiments are needed to determine the transmission constants for snow of various densities.

During the winter of 1914 the ground was thoroughly frozen when the heavy snow fell. In the snowfall of December 14, 1915, the ground was but little frozen and fairly dry. During 1914 a layer of slush and ice appeared at the bottom of the snow, as shown in Table 1. Since the snowfall of December 14, 1915, there has been little accumulation of slush or ice at the bottom of the snow, although the temperature has been above 32° much of the time and a rain of 1.35 inches fell on December 17–18, 1915. There was no appreciable difference in the appearance of the snow cover before and after this rain. The accumulated water on the ground surface before this rain was 3.34 inches, and following the rain it was 3.49 inches. This was accompanied by a decrease in depth of the snow layer from 23.5 to 14.5 inches and by an increase in density from 0.141 to 0.241. As shown by the above figures, practically none of the rainfall of December 17 or 18 remained in the body of the snow. A marked rise in the ground-water level underneath the writer's yard took place, however, a day or so following this rain, indicating that the rain had simply filtered for the most part through the snow and percolated into the ground in very much the same manner as if there had been no snow cover.

To melt 1 pound of ice or snow at 32° requires the addition of 143.8 b. t. u. or at 777.5 ft.-lbs. each, 111,804.5 ft.-lbs., or roundly 3.4 h. p. for one minute.

Let,

r = depth of rainfall, inches;
w = water equivalent of accumulated snow on ground in inches;
t_r = temperature of rain (°F.);
t_a = temperature of air (°F.).

We shall assume $t_r = t_a = t$, and that 27.72 cu. ins. = 1 pound of water. For melting by rain alone, there will be required a rainfall such that

$$(t-32°)\frac{r}{27.72}=143.8\frac{w}{27.72}$$

or,

$$(t-32°)r=143.8w$$

$$r=\frac{143.8}{t-32°}w$$

Thus to melt 1 inch of congealed water, or say 5 inches compact snow, or 10 inches loose fresh snow, with rain at 42° would require 14.4 inches of rain. The melting of snow by rain alone is a very slow process. High temperature, especially with direct solar radiation, is much more effective.

CONCLUSIONS.

Some of the experiments described in this paper must be considered as preliminary and somewhat crude. Those relative to heat absorption by snow will, in particular, bear repeating in the light of the experience gained, and with greater refinement.

The experiments and the writer's observations lead to the following conclusions which, it is believed, are correct:

1. With temperature below freezing, the snow settles by gravity without change in its crystalline structure.

2. If the snow melts at the surface or if warm rain falls on it, most of the water percolates down through the body of the snow, provided the latter is at about 32° temperature and a part of the water adheres to the snow crystals as a capillary film.

3. If alternate thawing and freezing occur or if the interior of the body of the snow has a temperature well below freezing when rain falls or when the surface is melting, the adhering films become frozen to the snow and increase the size and volume of the crystals, changing their crystalline form and increasing the density of the mass. This is apparently the cause of the snow becoming coarse grained with age. The infiltrated water melts some crystals, especially the smaller ones. The size of the pores is thus increased and the capillary supporting power of the snow decreased, as was observed in the experiments shown in figure 3.

4. There may thus result from alternate thawings and freezings, or from rain, a further increase in density independent of the decrease in depth of the snow.

5. Under suitable conditions of low snow temperature, rain may freeze at the surface, forming a crust.

6. When a thaw occurs after a cold snap, the snow at a little depth below its surface being much below freezing temperature, the water resulting from surface melting percolates to a slight depth in the snow and becomes fixed by the freezing of the liquid films on the crystals, forming stratification in the snow mass.

7. When snow and water are in temperature equilibrium (i. e., 32°), percolation and capillary action through the snow may take place in the same manner as the flow of water through a porous soil.

8. Snow in this condition will support a column of water against gravity having a height three to five times D in inches, where D is the snow density (water = 1).

9. The transmission constant for packed snow, density 0.64, was found to be about 2.28 inches depth per minute, which equals 273.6 feet per 24 hours for free downward percolation.

10. When snow stands on a sloping impervious surface, lateral flow will be proportional to the product of the depth of slush under the snow, the transmission factor, and the slope of the surface, jointly.

11. With thawing days and freezing nights, most of the water resulting from the melting of snow lying upon impervious ground will percolate to the bottom of the layer and may there be held by capillary action until subsequent cold converts it into a layer of ice. It may remain as ice until most of the snow above it is melted. This explains the layer of ice commonly observed around the margin of a snow bank as it melts, even when the snow bank lies on a steep slope.

12. The run-off to streams from melting snow, will lag behind the process of melting until, if melting temperatures continue long enough, nearly the whole snow mass will be converted into slush. In the meantime the run-off will take place only through the slow processes of capillary flow.

13. After the greater portion of the snow has been converted into slush subsequent heat—due to direct insolation or to warm rain—may rapidly break down the remaining capillary structure, and cause a relatively rapid flushing of water into the streams with resulting flood conditions. As snow melts ordinarily, the percolating water under the snow accumulates in low places, breaks through the obstructing barrier of slush into outlet channels and the actual rate of run-off is somewhat

greater than would be the case for uniform capillary flow along the surface.

14. The rate at which the snow is melted depends on the rate at which heat can be absorbed by the snow surface per unit area with air at the given temperature. The writer's experiments indicate that the melting constant is about 0.04 to 0.06 inch depth of water per 24 hours per degree of temperature above 32°F. Loose snow apparently absorbs heat at about the same rate as packed snow, but as the water equivalent of the former is lower, its rate of disappearance is much more rapid.

15. When snow overlies unfrozen ground, or frozen but porous and unsaturated soil, most of the water from melting percolates to the bottom of the snow layer and thence into the soil. The melting of snow or warm rain falling upon a snow cover under suitable conditions, is thus more favorable to the replenishment of ground water than would be an equal volume of rainfall on a bare surface, since in the presence of snow, surface run-off is greatly retarded and the opportunity for infiltration increased.

16. Under suitable conditions and especially in the woods where the ground is least frozen, a deep layer of snow on level ground may wholly disappear by invisible percolation without causing any surface run-off whatever. Where there is opportunity for infiltration, the melting of snow contributes more to the ground water and less to the surface run-off than would an equal volume of rain on a bare surface, and by providing a high ground-water level, the effect of the melting of snow cover may be felt for a longer time after the snow has disappeared than if an equal volume of rain had fallen at the same time.

METEOROLOGY AND SEISMOLOGY AT THE PAN AMERICAN SCIENTIFIC CONGRESS.

By C. FITZHUGH TALMAN, Professor of Meteorology.

[Dated: Weather Bureau, Washington, Jan. 20, 1916.]

In the Second Pan American Scientific Congress, which met in Washington from December 27, 1915, to January 8, 1916, inclusive, meteorology and seismology were represented by a subsection of Section II. All sessions were held in the auditorium of the Carnegie Institution.

On Tuesday morning, December 28, the Subsection on Meteorology and Seismology met in conjunction with the Subsection on Astronomy and Geodesy. Dr. R. S. Woodward, chairman of Section II, addressed the meeting, after which administrative business of the section was disposed of and a program of astronomical and geodetic papers was presented. The first separate session of the Subsection on Meteorology and Seismology was held on the afternoon of December 28.

The attendance in this subsection was gratifyingly large, and this branch of the Pan American Scientific Congress was probably more fully representative of the meteorological and seismological activities of the Americas than any scientific gathering ever before held. Owing to the length of the program, it was found necessary, after the first session, to read by title all papers the authors of which were not in attendance.

The following meteorologists and seismologists attended one or more of the sessions as members of the Congress:

Dr. C. G. Abbot, Smithsonian Institution, Washington.
Dr. H. Arctowski, New York Public Library, New York.
Prof. S. I. Bailey, Harvard College Observatory, Cambridge, Mass.
Dr. L. A. Bauer, Carnegie Institution, Washington.
E. A. Beals, U. S. Weather Bureau, Portland, Oreg.
Prof. W. R. Blair, U. S. Weather Bureau, Washington.
E. H. Bowie, U. S. Weather Bureau, Washington.
C. F. Brooks, Yale University, New Haven.
Prof. J. E. Church, jr., University of Nevada, Reno.
Dr. H. H. Clayton, Oficina Meteorológica Argentina, Buenos Aires.
Dr. I. M. Cline, U. S. Weather Bureau, New Orleans.
Prof. H. J. Cox, U. S. Weather Bureau, Chicago.
Prof. O. L. Fassig, U. S. Weather Bureau, Baltimore.
Prof. H. C. Frankenfield, U. S. Weather Bureau, Washington.
Rev. A. Galán, S. J., Woodstock College, Woodstock, Md.
Rev. M. Gutierrez-Lanza, S. J., Belén College, Habana.
Prof. A. J. Henry, U. S. Weather Bureau, Washington.
Prof. W. H. Hobbs, University of Michigan, Ann Arbor.
Prof. W. J. Humphreys, U. S. Weather Bureau, Washington.
Prof. E. Huntington, Yale University, New Haven.
Dr. T. A. Jaggar, Volcano Observatory, Hawaii.
Prof. H. H. Kimball, U. S. Weather Bureau, Washington.
Dr. C. J. Kullmer, Syracuse University, Syracuse, N. Y.
Dr. L. Landa, director general of public instruction, Honduras.
Dr. C. Lurquin, director, Observatorio Meteorológico del Instituto Médico, Sucre, Bolivia.
Prof. C. F. Marvin, chief, U. S. Weather Bureau, Washington.
Ing. J. C. Millás y Hernández, subdirector of the National Observatory of Cuba, Habana.
Dr. F. E. Nipher, Washington University, St. Louis.
W. G. Reed, Office of Farm Management, Department of Agriculture, Washington.
Rev. S. Sarasola, S. J., director, Observatorio del Colegio de Montserrat, Cienfuegos, Cuba.
Prof. J. Warren Smith, U. S. Weather Bureau, Columbus.
Dr. W. F. G. Swann, Carnegie Institution, Washington.
Prof. C. F. Talman, U. S. Weather Bureau, Washington.
A. H. Thiessen, U. S. Weather Bureau, Salt Lake City.
Rev. F. A. Tondorf, S. J., Georgetown University, Washington.
J. F. Voorhees, U. S. Weather Bureau, Knoxville.
Prof. R. DeC. Ward, Harvard University, Cambridge, Mass.
E. L. Wells, U. S. Weather Bureau, Boise.
Dr. R. S. Woodward, president, Carnegie Institution, Washington.

The attendance included, in addition to these persons, several officials and employees of the Weather Bureau and others who were not members of the Congress.

A brief account of the proceedings follows:

SECOND PAN AMERICAN SCIENTIFIC CONGRESS, WASHINGTON, DECEMBER 27, 1915–JANUARY 8, 1916.

MINUTES OF SUBSECTION IIB, METEOROLOGY AND SEISMOLOGY.

First session, Tuesday, December 28, 1915, 2:30 p. m.—The meeting was called to order by Prof. C. F. Marvin, chairman of the subsection, who delivered an address of welcome.

The following papers were read:*

*"Investigations on the prediction of barometric variations." Rev. S. Sarasola, S. J.
Discussion by Messrs. Lurquin and Frankenfield.
*"Origin and course of West Indian hurricanes." J. C. Millás.
Discussion by Messrs. Sarasola and Gutierrez-Lanza.
"Thunderstorms." W. H. Alexander. (Read by Prof. A. J. Henry.)
Discussion by Messrs. Church, Clayton, and Peabody (of Section I).
"Agricultural meteorology." Prof. J. Warren Smith.
Discussion by Messrs. Church, Frankenfield, and Voorhees.

Second session, Wednesday, December 29, 1915, 2:30 p. m.—Prof. C. F. Marvin, presiding.

Dr. Woodward announced the membership of the committee on resolutions, which he had been authorized to appoint at the first general meeting of the section, viz: Dr. Woodward (chairman), Prof. Marvin (U. S. A.), Sr. Millás (Cuba), Dr. Clayton (Argentina), and Prof. Morandi [1] (Uruguay).

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*Papers whose titles are preceded by an asterisk are published in abstract on another page of this REVIEW. Some of the papers presented will appear in full in later issues of the REVIEW—C. A., jr.

[1] Prof. Morandi was found not to be in attendance at the congress, and was replaced by Dr. Lurquin (Bolivia.)—C. F. T.

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The following papers were read:

*"Climatic control of cropping systems and farm operations." J. F. Voorhees.
Discussion by Messrs. Fassig and Smith.
*"The climate of Cuba." Rev. M. Gutierrez-Lanza, S. J.
Discussion by Mr. Millás.
"The pleionian fluctuations of climate." Dr. H. Arctowski.
Discussion by Messrs. Huntington, Clayton, Hobbs, and Kullmer.
*"The Ferrel doctrine of polar calms and its disproof in recent observations. Prof. W. W. Hobbs.
Discussion by Clayton.
"The meteorological influences of lakes." E. R. Miller. (Read by title.)
*"The position of meteorology among the sciences." C. F. von Herrmann. (Read by title.)

Third session, Thursday, December 30, 1915, 9:30 a. m.—Prof. C. F. Marvin, presiding.

The following papers were read:

"Frequency, amount, and characteristics of rainfall and hailstorms at Villa Colón, Montevideo, from 1888 to 1914." Luis Morandi. (Read by title.)
"The River Plata." [2] Hamlet Bazzano. (Read by title.)
*"The climate of Salt Lake City." A. H. Thiessen.
Discussion by Messrs. Fassig and Wells.
*"The economic aspects of climatology." Edward L. Wells.
Discussion by Prof. Smith.
*"Sleet and ice storms in the United States." Prof. H. C. Frankenfield.
Discussion by Messrs. Henry, Arctowski, Brooks, and Blair.
"Forecasts of weather favorable to the increase of forest fires." E. A. Beals.
Discussion by Messrs. Wells and Henry.

Fourth session, Friday, December 31, 1915, 2:30 p. m.—Prof. C. F. Marvin, presiding.

The following papers were read:

*"Monthly storm frequency in the United States." Prof. C. J. Kullmer.
Discussion by Messrs. Henry, Arctowski, and Huntington.
"The thunderstorms of the United States as climatic phenomena." Prof. R. DeC. Ward.
Discussion by Messrs. Cox and Arctowski.
*"Solar activity, cyclonic storms and climatic changes." Prof. Ellsworth Huntington.
Discussion by Prof. Nipher.
"The influence of the Great Lakes upon the movement of high and low pressure areas." Prof. H. J. Cox.
Discussion by Messrs. Church, Henry, and Clayton.
"The duration and intensity of tropical rains." Prof. O. L. Fassig.

Fifth session, Monday, January 3, 1916, 9:30 a. m.—Prof. C. F. Marvin, presiding.

The following papers were read:

*"Climatic fluctuations in historic times." Rev. Antonio Galán, S. J.
Discussion by Father Gutierrez-Lanza.
*"Temperature conditions at New Orleans, as influenced by subsurface drainage." Dr. I. M. Cline.
Discussion by Messrs. Smith, Cox, Nipher, Clayton, Fassig, and Humphreys.
*"Snow surveying—its problems and their solution." Prof. J. E. Church.
Discussion by Messrs. Thiessen and Wells.
"Introduction to the study of the solar relations of meteorology." German Barbatto and Pedro Esquerré. (Read by title.)
"The Callendar sunshine recorder." Prof. A. E. Douglass. (Read by title.)
"Measurements of the intensity of solar and sky radiation." Prof. H. H. Kimball.
Discussion by Dr. Bauer.
*"Atmospheric electric observations aboard the 'Carnegie'." Dr. W. F. G. Swann.
Discussion by Messrs. Humphreys and Bauer.
"Frost in the United States." Wm. Gardner Reed.
Discussion by Messrs. Fassig, Clayton, and Voorhees.
"Some results of aerological observations." Prof. W. R. Blair.

Sixth session, Wednesday, January 5, 1916, 9:30 a. m.—Prof. C. F. Marvin, presiding.

The following papers were read:

*"Fog forecasting in the United States." Prof. H. C. Frankenfield. (Read by title.)
"River service of the Weather Bureau." Prof. A. J. Henry. (Read by title.)
"The principles involved in predicting high-water stages in 'flashy' streams, with special reference to the scheme for the Savannah River at Augusta, Ga." E. D. Emigh. (Read by title.)
"Forecasts of river stages and floods in the Ohio Valley—their importance to commerce and in conserving life and property." W. C. Devereaux. (Read by title.)
"The principal geophysical bases of modern seismology." Dr. Santiago I. Barbarena. (Read by title.)
"Organization of macroseismological observations in America." Count de Montessus de Ballore. (Read by title.)
*"Wind velocity and elevation." Prof. W. J. Humphreys.
"The collection of seismological data in the United States." Prof. W. J. Humphreys.
Discussion by Dr. Jaggar.

Dr. Woodward, chairman of the section, read a resolution drawn up by the committee on resolutions, as follows:

Whereas the First Pan-American Scientific Congress formulated and voted the following resolution: "The Fourth Scientific Congress (First Pan-American) recommends to the American Republics the installation of meteorological organizations to serve as a basis for the establishment of a Pan-American meteorological service, which is also recommended":

Resolved. That the Second Pan-American Scientific Congress confirms this resolution, and adds that it is most desirable for the Republics not yet possessing organized official meteorological services to establish such as soon as practicable.

This resolution was unanimously adopted, for submission to the executive committee of the congress.

*"Bolivian meteorology." Dr. Constant Lurquin.
Discussion by Father Sarasola.
"First steps of Venezuela in the field of meteorology." Dr. Luis Ugueto. (Read by title.)
*"General organization of the services of the National Meteorological Bureau of Uruguay." Hamlet Bazzano. (Read by title.)
* "Present condition of meteorology and seismology in Honduras." Luis Landa.
"Résumé of the organization of the meteorological service of Chile." (Contributed by the Instituto Central Meteorológico y Geofísico de Chile. Read by title.)
"National Observatory of the Republic of Cuba. Brief sketch of the services established under the direction of this observatory." Luis G. y Carbonell. (Read by title.)
"The Argentine meteorological service." H. H. Clayton.
Discussion by Messrs. Smith and Talman.
"Contributions to Colombian meteorology." Jorge Alvarez Heras. (Read by title.)
"The organization of meteorology and seismology in the United States." Prof. C. F. Marvin.

The chairman brought before the attention of the meeting a proposal to form a Pan-American Meteorological Association, which was referred to the members for informal discussion after the session.

A vote of thanks was extended to the Carnegie Institution for the use of the auditorium.

On motion of Dr. Lurquin a vote of thanks was extended to the United States Government and to Prof. Marvin and other officials of the United States Weather Bureau for their collaboration in the work of the subsection and for hospitalities accorded the members.

C. F. TALMAN,
Secretary, Subsection IIB.

[2] The spelling here followed is that adopted by the United States Board on Geographic Names.—EDITOR.

SELECTED ABSTRACTS OF PAPERS AT THE PAN-AMERICAN CONGRESS.

NATIONAL METEOROLOGICAL INSTITUTE OF URUGUAY.

By HAMLET BAZZANO.

[Author's abstract.]

The author begins with a description of the work carried on in the meteorological section of the institute and of the instruments of the section employed in the study of atmospheric electricity, of clouds, of telluric currents and their physical laws, of temperature and gravity, as well as the careful study of winds, which is a meteorologic factor of the greatest importance for the study of the estuary of the Plata River.

Incidentally he refers to the propaganda carried on by the institute for the purpose of eliminating the general tendency to make use of averages exclusively, analyzing the remote influences and anomalies in the course of the curves of the registers.

Then he analyzes the great differences between the meteorologic conditions of different points in the country and describes the work of the institute in the determination of the meteorologic data referred to and of the salinity, temperature, and other characteristics of the waters of the Plata, a study which has served for determining the propagation in various conditions of the tidal wave from the Atlantic.

He refers to the work undertaken some years ago by the institute of fixing the relation between certain classes of crimes and the state of the atmosphere, noting as a result of this work a parallelism between the increase of temperature and humidity and of the delinquencies in Montevideo. The results of five or six more years of observations are being awaited before attempting to draw conclusions on this subject.

The work done by the central observatory of the institute in the making of a weather map is then briefly described. Argentina, Brazil, and Uruguay and other countries of the southern part of the continent contribute to this work.

The work done by the section of the official time is also described. This section has charge of the transmission of the time to mariners, to the city three times a day, and to different points of the city where there are electric clocks, and the setting and regulating of chronometers and of clocks, especially those used in navigation.

The paper concludes with a description of the work done by the semaphoric service recently annexed to the National Meteorological Institute.

SNOW SURVEYING: ITS PROBLEMS AND THEIR SOLUTION.

By J. E. CHURCH, Jr.

[Author's abstract.]

The problem of precipitation and run-off has become the dominant meteorological problem in the semiarid States where irrigation is fundamental to agriculture.

Most of the requisite precipitation falls in the form of snow upon the higher mountains, where it is conserved until summer. The estimate of this precipitation and the amount of water available from it is complicated by the fact that for Nevada and probably other States reservoirs impound only 5 per cent of the water used in irrigation.

Apparatus.—Since the precipitation in this region is limited and must be used to the best advantage, the seasonal forecast should be based upon the most accurate methods compatible with the service rendered. Estimates of available water should preferably be based upon surveys of the snow fields themselves.

The seasonal snow gage is unsatisfactory, because of the strong wind currents, the great depth of snow, local divergencies in precipitation, probable freezing of the contents, and consequent difficulty in measuring the water content in March or April, when seasonal estimates should be made. A gage heated by acetylene gas would be expensive, and the cost of a number of seasonal gages of any type would be prohibitive.

Snow stakes in ordinary numbers are also unsatisfactory, except in forested regions or pockets of the mountains where the snow fields are protected from erosion and shifting by the wind. It is also questionable whether stakes of sufficient strength and height and in requisite numbers can be erected at reasonable expense.

Snow stakes, moreover, afford no clue to the exact water content of snow. However, the analysis of 1,900 measurements of the depth and water content of the snow on exposed mountain peaks has resulted in a table of relative density based on season and depth from which the water content of wind-driven snow can be approximately determined by an ordinary rod, if used along definite courses. It is hoped that the analysis of several thousand measurements already made at lower elevations in the forests will result in a similar table for snow laid under more tranquil conditions.

The snow sampler in its most highly developed form solves the difficulties confronting the seasonal gage and the snow stakes and can be operated anywhere that two men on snowshoes can go.

Methods.—The unit in snow surveying should be conducted to determine local divergencies in precipitation. This is especially necessary where the seasonal estimate is based upon the snow cover of the total watershed rather than upon the percentage relationship of the snow cover in characteristic parts of the basin to the corresponding snow cover of some season or series of seasons whose run-off is known.

The courses should be long and exactly marked, and measurements should be made at definite intervals. Where possible, level ground should be selected in order to obtain a mean between the overloaded northern slopes and the thinly covered southern ones.

The method of percentage relationship is probably simplest, and estimates have been accurate within 12½ per cent.

By careful surveys in one basin it is possible to forecast for the next adjoining basin as well.

TEMPERATURE CONDITIONS AT NEW ORLEANS AS INFLUENCED BY SUBSURFACE DRAINAGE.

By ISAAC M. CLINE.

[Author's abstract.]

The frequent occurrence of high temperatures at New Orleans in recent years, which general meteorological conditions did not account for, indicated that some local influences are responsible for their occurrence.

New Orleans is situated near the center of the great Mississippi Delta. The elevation of a large part of the city is not much above sea level, and the ground water under ordinary conditions was level with the surface of the ground. Storm water and water from other sources was carried away in a sluggish manner over the surface. Much of the country surrounding New Orleans was covered the greater part of the time with water from the Gulf of Mexico. These conditions exerted a material influence on temperature conditions, giving a climate insular in many respects.

Natural physical conditions as they existed were not conducive to healthfulness and the water formed breeding places for disease-carrying mosquitoes and other pests. To relieve this condition, subsurface drainage was put into operation in 1900, and a sewerage system to carry off sewage water was installed in 1903. The operation of these drainage systems has carried off the surface water rapidly and lowered the level of the ground water 6 to 8 feet below the surface of the ground. Large areas around New Orleans have been drained, so that ground which was formerly marsh or with the ground-water level with the surface of the land is now under ordinary conditions dry ground.

The effects of these artificial changes in physical condition on solar and terrestrial radiation have materially affected temperature conditions. Prior to 1900 the temperature at New Orleans had never reached 100°F., but since that year temperatures of 100°, or above, have been recorded seven times. During the 15 years prior to the installation of subsurface drainage in 1900, temperatures of 95°, or above, were recorded on 35 days, while during the 15 years 1900 to 1914, inclusive, the period during which subsurface drainage has been in operation, temperatures of 95°, or above, have been recorded on 74 days, an increase of 122 per cent over that of the period just prior to the installation of subsurface drainage. Other temperatures have also been materially influenced by the artificial changes in physical conditions.

The summer of 1915, which is not included in the two periods compared, had 25 days with the temperature 95°, or above, only 10 days less than the total number in the 15 years ending with 1899, just preceding the installation of subsurface drainage. The precipitation during the summer of 1915 was above the normal, but the number of rainy days was only about half the average. There were periods of 6 to 8 days in succession without rain, which gave the changes made in physical conditions an opportunity to show their influences. Similar periods without precipitation prior to subsurface drainage, even in months when the amounts were below the normal, did not give high temperatures comparable with those of 1915 either as regards frequency or intensity.

FOG FORECASTING IN THE UNITED STATES.[1]

By H. C. FRANKENFIELD.

[Author's abstract.]

Fog, definition of.—A surface cloud caused (1) by the mixing of two bodies of air of unequal temperature, one or both of which has a high vapor content, and (2) by the cooling of a body of moist, free air to a temperature lower than its dew point.

Scope of paper.—To consider the character, extent, etc., of the physical causes of fog, with a view to forecasting the approach of dense fog on the great navigable waters within or immediately adjacent to the United States, viz, coasts of the Great Lakes, the Atlantic, and the Gulf of Mexico.

[1] The full text of this paper will appear in the manual on forecasting, in preparation by the U. S. Weather Bureau.—C. A., jr.

LAKE REGION.

Seasonal distribution of fog.—February is the month of greatest fog frequency on the lakes, and July and August the months of least frequency, with more marked seasonal characteristics and greater frequency over the southern portion of the district.

Conditions favorable for fog formation.—(1) Low pressure on the leeward side of the lakes and relatively high pressure on the windward side, with a weak gradient (0.10 inch in 100 to 250 miles). (2) Temperature differences more or less marked between the water and land surfaces. In about two-thirds of the cases the water temperature was the lower. (3) Relative humidity above normal, averaging above 90 per cent. (4) The occurrence of precipitation from 24 to 36 hours previous to the fog, usually to the westward and southward of the lakes. (5) Low wind velocities, less than 15 miles an hour (less than 6 miles above one-third of the time).

Region of maximum frequency.—From the southern third of Lake Michigan eastward over extreme southern Lake Huron to western Lake Erie.

Form of fog covering.—Usually uniform like a blanket, but quite frequently in banks, or bands, both along shore and over the water. The blanket form is most prevalent when the low-pressure systems are moving slowly toward the lakes.

ATLANTIC COAST.

Regions of maximum frequency (with diagram).—The region of greatest frequency is the eastern coast of Maine with a steady decrease to almost zero at Key West, Fla., with a few explainable exceptions.

(1) Fogs are most frequent where the water temperatures are lowest.

(2) Fog frequency in any given locality is proportional to the differences in temperature between the land and water surfaces.

Geographic distribution of fog.—This is almost entirely a question of pressure distribution and resulting wind direction. Fog occurs at times along the entire coast from Eastport, Me., to Jacksonville, Fla., and from thence westward along the Gulf coast to the mouth of the Rio Grande; at other times from the Maine coast to Hatteras, N. C., to Cape May, N. J., to New York, etc. Another fog type extends along the ocean from northeast to southwest, touching the coast at only a few points, such as Nantucket, Mass., and Hatteras, N. C.

Seasonal distribution (with table).—Fog is most frequent in midsummer on the New England coast, and least frequent in winter; most frequent in winter and early spring on the Middle and South Atlantic coasts, and least frequent in midsummer.

GULF OF MEXICO.

The same general rules apply to Gulf of Mexico fogs as to those of the Lakes and the Atlantic coast. The region of maximum frequency occurs between the northwest coast of Florida and the northeast coast of Texas, the number of foggy days increasing from east to west. (Diagram and table.)

The season of greatest frequency is winter, and that of least frequency summer, fog being very rare in the latter season owing to the high temperatures and the high vapor content of the air.

GENERAL NOTES.

(1) Fog belts appear to "travel," generally from west to east, but occasionally in the opposite direction.

(2) A good fog type for the South Atlantic and Gulf coasts is high pressure over Bermuda and low pressure over Texas and Oklahoma, with a very weak gradient.

(3) Fogs form frequently on the Atlantic coast with low pressure north of Lake Superior, moving northeastward.

(4) The fog belt is not always continuous along a coast.

SLEET AND ICE STORMS IN THE UNITED STATES.

By H. C. FRANKENFIELD.

[Author's abstract.]

Definition of terms.—Sleet is precipitation that occurs in the form of frozen, or partly frozen, rain, and is formed by rain falling from a relatively warm air stratum into and through another air stratum that is sufficiently cold to freeze some or all of the rain drops. Mixtures of snow and rain are not sleet; neither are mixtures of hail and rain. A modification of sleet, but not true sleet, is rain that actually falls to the surface as rain, but freezes as soon as it touches the surface. This is the form that causes the greatest damage.

The etymology of the term is uncertain. Some of the earlier equivalents are the Middle High German "Sloze," the German "Schlosse," and the Norwegian "sletta," the latter meaning to "slap." Sleet and hail are different, both formatively and structurally.

Geographical distribution.—Sleet storms are very rare west of the Rocky Mountains and along the eastern slope of the mountains. The region of greatest frequency is over the great interior valleys, and from thence eastward, that is, over the section traversed by the principal low pressure systems. (See diagram.)

Seasonal distribution.—The months of greatest sleet frequency are January and February over the Great Valleys, the Lower Lakes, and the Middle Atlantic States, and March and December over the Upper Lakes. The Upper Lake storms are rarely so severe as the others. Sleet has been observed as late as May and as early as October 3.

Conditions favorable for sleet and ice storms.—(1) Low pressure and high temperature to the northward; 72 per cent well developed and 28 per cent fairly so; no failures.

(2) Steep pressure and temperature gradients to the northward; 69 per cent well developed and 12 per cent fairly so; 19 per cent failed.

(3) Surface temperatures below the freezing point, usually between 22°F. and 28°F.

(4) Moderately high pressure and high temperature over the East Gulf and South Atlantic States. This occurred in 70 per cent and failed in 30 per cent of the cases.

(5) Northward looping of the isotherms (surface inversion). True in 88 per cent of the cases.

(6) Gentle to fresh northerly winds, increasing by the time sleet begins. Almost uniformly true.

(7) Low pressure trough between two highs, trending from southwest toward northeast. Low center, usually moving from southwest.

Sleet or snow, which?—(1) The steep temperature gradients to the northward of the storm center that precedes sleet are not necessarily in advance of heavy snow.

(2) The high temperatures over the Gulf and South Atlantic States necessary to sleet formation are absent before and during heavy snows.

(3) The warm southerly winds over the Gulf and South Atlantic States come from warm water surfaces, and carry a much larger water-content than winds from any other directions. Out of 34 cases of sleet, 29 were preceded by warm southerly winds over the South Atlantic and East Gulf States, while out of 48 cases of heavy snows, 28 were preceded by cool weather over the South and only 5 by warm weather.

CLIMATIC FLUCTUATIONS DURING THE HISTORIC EPOCH.

By ANTONIO GALÁN, S. J.

[Author's abstract.]

The investigations which Dr. Ellsworth Huntington, professor at Yale University, has made in the ruins which are found in an extensive area in southern Arizona, New Mexico, Yucatan, and Guatemala have cleared up in a great measure the difficult problem of the climatological fluctuations in historic times.

From these investigations the deduction is made that numerous tribes inhabited these regions, engaging principally in agriculture, while at the present time the cultivation of the soil is impossible.

A study of the terraces of America and their comparison with the investigations of Penck in Asia leads to the same conclusion.

Finally, the method of investigation introduced by Dr. Andrew E. Douglass, professor of the University of Arizona, in the study of the development of the pines of Arizona and New Mexico, and applied by Dr. Huntington to the sequoias of California, is still another argument in favor of this hypothesis. The curves which represent the annual development of these trees in periods of from 300 to 500 years present notable variations. These variations appear to be due to climatic fluctuations, since the annual development of trees is determined by their alimentation, and this depends in great part upon the amount of rainfall.

If this is true, the investigations made of the development of trees will indicate not only that there existed notable climatic variations in historic times but also that these variations were in the nature of pulsations.

All this leads to the belief that the cause of these fluctuations must be sought in the displacement of the great climatic zones of the earth. In historic times climatic variations were probably of the same character as those of the glacial period. Regions which are passing through a similar period are those of permanent high pressure. According to this a part of the United States might be under the influence of an area of high pressure during the whole year. The storms which to-day cross from the Pacific to the Atlantic, providing the greater part of the precipitation in the regions which they cross, would be obliged to move southward, thus supplying an abundant rainfall for the arid regions of the Southwest.

Investigations which have been made of the ruins found in the forests of Yucatan and adjacent regions indicate that the climate there was drier, more varied, and less enervating than at present. This confirms the above ideas; for if the storms of the West were pushed toward the South it might result that regions like Yucatan would have the varied climate which characterizes the central part of the United States. The trade winds would be destroyed or pushed toward the south, causing abundant and continuous rains, thus prolonging the dry season and making the climate fresher and more varied.

POSITION OF METEOROLOGY AMONG THE SCIENCES.

By CHARLES F. VON HERRMAN.

[Author's abstract.]

This paper begins with a critical study of the criteria of Comte, Bacon, Pearson, and Spencer in the classification of the sciences, with the object of discussing the position of each one of these scientists with reference to meteorology.

Pearson places meteorology among the sciences purely descriptive. Perhaps he is right. Meteorology is yet an imperfect science, because its phenomena are extremely complex, subject to the influence of innumerable factors. Physics and astronomy also passed through an epoch of imperfection. Even to-day they are imperfect in the analysis of problems of great difficulty; but day by day they were perfected up to the point in which it was possible to formulate their data mathematically. On account of the nature of things it is not possible to have an absolutely exact science, and much less can there be exactness in meteorology. While astronomic phenomena, for example, depend upon the universal law of gravitation only, meteorological phenomena are subject to solar radiation, to the influence of heat on the air and the vapor which it contains, and the configuration of the earth and its rotation. Systematic progress in the field of meteorology is therefore very difficult, as has been the case with chemistry and physics which are based on experimentation; because this experimentation, besides being extremely difficult, attempts to determine laws of the phenomena of the whole planet. But in spite of this complexity it has been possible in recent years to formulate the mathematical laws by which meteorological phenomena are controlled. These have such a firm basis that meteorology has now acquired a high place in the classification of natural sciences.

Meteorology is divided, like astronomy, into static and dynamic: Climatology and dynamic meteorology. Climatology is descriptive and its study has to do with the average condition of the atmosphere in different places, especially in its relation to organic life. Dynamic meteorology is the more important division of the science, and the study of its phenomena is extremely complicated, requiring a consideration of the pressure, temperature, and movement of the air. The study of its phenomena requires the solution of problems of physics and mathematics of the greatest difficulty.

The progress of the mathematical study of meteorology has been along two lines: One leads to the theory of cyclonic movements and the other to the discussion of the thermodynamic principles related to the condensation of humidity in clouds and rain and to the changes of temperature dependent upon the expansion and contraction of the air. The author analyzes some of the works and mentions others which mark the progress of the science of meteorology, as those of Ferrel, Mohn, Overbeck, Espy, Bigelow, Margules, etc.

The paper concludes with a classification of the sciences according to Pearson, based on the "mutual relation of the sciences and their continuous development."

THE FERREL DOCTRINE OF POLAR CALMS AND ITS DISPROOF IN RECENT OBSERVATIONS.

By WILLIAM H. HOBBS.

[Author's abstract.]

The theory of William Ferrel that the poles of the earth are surrounded by areas of calm, surrounding which is a whirl of persistent westerly winds, was promulgated as a part of a larger scheme of atmospheric circulation and at a time when meteorological observations had not been carried far into the polar regions. Objections to the theory were found so soon as successful explorations had been pushed southward beyond the Antarctic Circle; but the anticyclonic conditions which were there encountered and found to be in conflict with the Ferrel theory were explained as due to their position near the geographic pole.

In the years 1910 and 1911 the writer pointed out, upon the basis of the scientific data then available from the Antarctic regions, that the control of atmospheric circulation is there determined not by latitude, but by the vast blanketing dome of ice (the continental glacier) enwrapping the continent. This cold snow-ice mass causes fierce storms and prolonged calms to alternate above it in strophic succession; and the storms being directed outward, or radially, draw down with the air from the upper levels the ice needles that make up the cirrus and cirroid clouds. During their descent these ice needles are first melted and later evaporated, but when the resultant vapor approaches the cold ice surface it is precipitated out again as snow or as fine ice needles.

The surface system of winds above a continental glacier being thus found to be centrifugal, the slopes of the glaciers are visited by blizzards fiercer than any known elsewhere, while the central areas are characterized by variable light winds, by much vapor content, and by frequent falls of fine ice needles often while the sun is shining. It is proper, therefore, to regard the vast continental glacier of the Antarctic, and in less degree that which lies on the Greenland Continent, as the poles, respectively, south and north, in the atmospheric circulation. It is at these poles that the high level poleward currents of air and the moisture which has been locked up in the cirri are in large part returned to the circulation at the surface levels and directed equatorward.

Since this theory was first promulgated in the year 1910 the southern geographic pole has been twice attained, and several crossings of the ice upon the Greenland Continent have been carried out. The meteorological data from these expeditions have confirmed in a convincing manner all the essential attributes of the glacial anticyclones.

WIND VELOCITY AND ELEVATIONS.

By W. J. HUMPHREYS.

[Author's abstract.]

Everyone knows, from mere casual observations of tree tops and such floating objects as clouds, leaves, and dust, that wind velocity increases with elevation. Careful measurements show: (*a*) That it is quite rapid through the first few hundred meters, the region of surface disturbance; (*b*) that through the next layer, roughly 500 to 1,500 meters, it is comparatively slow and irregular; (*c*) that from about 1,500 meters elevation to the isothermal level it is approximately uniform and moderately rapid; and (*d*) that above the isothermal level it generally has a negative value.

From 4 or 5 to 10 or 11 kilometers elevation the velocity of the wind increases at approximately the same rate that its density decreases. Hence, between these levels the product of velocity by density remains roughly constant, a law first formulated by Axel Egnell.

These important relations of wind velocity to altitude depend essentially upon two factors, temperature distribution and earth rotation, from which they logically may be deduced by the aid of a few suitable equations.

SOLAR ACTIVITY, CYCLONIC STORMS, AND CLIMATIC CHANGES.

By ELLSWORTH HUNTINGTON.

In recent publications the author has advanced the hypothesis that climatic variations, both of the present and the past, may be due in large measure to variations in the intensity and locations of the belts of cyclonic storms, and that these in turn may be due to variations in solar activity. The basis of the hypothesis is the observed fact that when sun spots are numerous and the sun gives out more heat than usual, the earth's surface is abnormally cool and the number of cyclonic storms and the general intensity of the atmospheric circulation are above the average. The sun's activity, whether by means of greater heat or greater electrical radiation, appears to cause more cyclonic storms. In the centers of such storms there is an upflow of warm air. Increased storminess must carry much warm air into the upper layers of the atmosphere, and thus cool the lower layers.

Examination of charts of storminess in North American and Eurasia shows that on both continents there is a tendency toward the development of a subtropical storm belt, as well as of the usually recognized boreal belt. The evidence of the subtropical belt is found in areas of increased storminess in Kansas and east of the Appalachians in the United States, and in closely similar but much more pronounced centers of storminess in northern Italy and Japan in Eurasia.

At times of many sun spots the two belts tend to become more distinctly separated, while the component parts of the subtropical belt tend to coalesce into a single belt in each continent, as is shown by the records of the past 30 or 40 years. Each belt tends to be shoved outward from the center of the continent, so that storminess there decreases, while on the periphery it increases. The increased storminess of the main northern belt continues through a large part of the year. In the subtropical belt, however, the increase in the number of storms occurs chiefly at the beginning of winter and in the late spring; that is, at the beginning and end of the rainy period in countries where the Mediterranean type of rainfall prevails.

In the past there appears to have been a period of exceptional climatic stress, culminating in the fourteenth century. Evidence of this is derived (1) from the expansion of lakes in western and central Asia, (2) the growth of trees and the expansion of lakes in the similar climatic area of the United States, (3) intense cold, excessive storminess, and consequent economic distress in Scandinavia and around the North Sea, and (4) an increase of ice, together with other disasters, such as the failure of crops, in Greenland. The places from which the evidence is derived are located in the regions where storminess now increases at times of many sun spots. Although data are scarce, there is some indication that the fourteenth century was a time of unusual sun-spot activity. The final conclusion seems to be that changes in solar activity are a chief cause of present climatic fluctuations and also of the much larger climatic changes that have taken place in the past.

MEASUREMENTS OF SOLAR AND SKY RADIATION.

By HERBERT H. KIMBALL.

[Author's abstract.]

This paper describes different methods of measuring the intensity of solar radiation and types of apparatus employed, and also recording apparatus for obtaining continuous records of the total solar and sky radiation received on a horizontal surface.

Measurements made at different stations of the Weather Bureau are summarized; and those for Washington are discussed briefly. The following are among the more important points developed:

The absolute monthly maxima of solar radiation intensities, measured about noon on a surface normal to the direction of incidence of the solar rays, vary but little throughout the year at Washington, show minimum values in the summer at Santa Fe, N. Mex., and at Madison, Wis., show a maximum in the early spring and a minimum in summer.

With a clear sky the daily totals of solar and sky radiation received on a horizontal surface at Washington exceed 750 gram-calories per square centimeter early in June and are but little in excess of 300 calories in the latter part of December. The average daily amounts at these two seasons, including all sorts of weather, are 70 per cent and 55 per cent, respectively, of what is received on clear days.

From March 10 to September 10 the heat received from the sun and sky on clear days on each square meter of horizontal surface is equivalent to the energy required to run twenty-five 40-watt electric lamps for 7 hours.

MONTHLY STORM FREQUENCY IN THE UNITED STATES.

By C. J. KULLMER.

A brief summary of the author's previous work on the storm frequency of the United States is given. The present investigation covers the 30-year period 1883–1912, and furnishes a 30-year map of the distribution of storms for each month and also three 10-year maps for each month covering the same period. A comparison of the three 10-year periods shows the extent of variability of storm frequency and discloses a remarkable constancy of the general storm area, increased storminess intensifying areas of normal high frequency. From a discussion of the figures for western Canada and for the Southwestern States, the conclusion is reached that an actual change has taken place in those regions. A general progressive southerly shift of the storm area is revealed by a detailed study of the abrupt northern boundary of the storm area.

PRESENT CONDITION OF METEOROLOGY AND SEISMOLOGY IN HONDURAS.

By LUIS LANDA.

[Author's abstract.]

Under the heading of present conditions the author describes the geographic position of the Republic of Honduras and the atmospheric phenomena of that country, such as rainfall, frost, fog, hail, mist, rainbow, lightning, winds, meteorites, giving important data concerning each one.

In the second part of this paper, entitled "Seismological Phenomena," the author sets forth the most important phenomena in this field which have occurred in Central America, such as the eruption of Cosiguina, which took place January 20, 1835.

The author then describes the only meteorological station in Honduras. This station is situated in Camayagüela, 14° 8′ N. and 87° 15 W. It is located at an altitude of 914 meters above sea level.

With reference to the needed stations the author is of the opinion that four meteorological and seismological stations distributed as widely as possible would be sufficient.

The last part of the paper contains a table of meteorological data collected by the Observatory of Camayagüela during the month of July, 1915.

THE CLIMATE OF CUBA.

By MARIANO GUTIERREZ-LANZA, S. J.

[Author's abstract.]

After some general considerations with reference to the benefits of atmospheric circulation and the laws governing it, the author observes that one of the best points from which to study meteorology is the city of Habana, situated on the border of the tropical zone between the equatorial and polar regions, where the atmospheric circulation takes its rise and receives its greater impulse. At this point is situated the observatory of the College of Belén, which is about to conclude 58 years of very complete observations which constitute the basis of the present study.

The study of the material with which the paper properly deals is preceded by three important chapters. In the first the geographic position of Cuba is given, the configuration of the ground, with its mountain and river systems, is described and the general ocean and atmospheric currents which affect the climate of the island are mentioned. In the second a complete relation is given of the series of observations made in Cuba; that is, all the existing materials which serve as a basis for the study of the climate of Cuba. In the third preliminary chapter the circumstances which give value to the collection of the observatory of Belén are set forth, since those data have furnished the materials for the construction of the tables and curves contained in this paper. The geographic position of the observatory, its situation within the city of Habana, the conditions under which the instruments are exposed and the quality of the same, the hours of daily observations and the phenomena noted, together with an outline of the history of the changes which have occurred in the form of a publication of the observations from the foundation of the observatory up to the present time, all are included.

The body of the study treats principally of the climate of Habana. Here the following climatic factors are considered separately: Atmospheric pressure, temperature in the shade, relative humidity, vapor tension, rainfall, and the laws of the prevailing winds. The study of these factors is accompanied by four tables for each one, three of which show the daily variation in each phenomenon and the fourth the most salient data of the same. Furthermore, curves showing the daily variation in each month of the year as well as the annual variation have been constructed. The study contains likewise a plate showing the curve of the annual variation in atmospheric pressure in other islands of the West Indies. This plate shows clearly the existence of a second abnormal barometric maximum for July.

Rainfall in Habana and its distribution form an interesting part of the study. In tabular form a complete history of rainfall in the Cuban capital from 1859 to 1914 is given. In another table general data of importance with reference to precipitation are given. To these are added two others, one of which is graphic, of the annual rainfall of the whole period. Finally the physical laws of winds are studied. The study is accompanied by a table which indicates the relative frequency of the various directions of the prevailing winds in Habana. The daily average velocity of the wind for each month is given.

In a supplement to his study the author treats briefly the climatic factors, atmospheric pressure, temperature, rainfall, and winds at a number of stations distributed throughout the island. Tables showing monthly and annual averages of the first three factors mentioned above are given.

BOLIVIAN METEOROLOGY.

By CONSTANT LURQUIN.

[Author's abstract.]

The present report on meteorology in Bolivia is a memoir that relates to the last subject indicated in the subsection of meteorology of the Second Pan-American Scientific Congress. This work has for its object to make known, as far as possible, the present organization of meteorology in Bolivia. Also to indicate the pressing needs that demand a rational study of meteorological phenomena.

The following subjects are considered in this report:

I. Meteorological stations: (1) Geographic coordinates and height above sea level, (2) publications of the results of the observations, (3) entry of observations, (4) meteorological phenomena observed.

II. Bolivian meteorology: (1) Official project for a national meteorological service, (2) telegraphic information.

III. Conclusion—Supplements: (1) A list of the studies published by the staff of the meteorological section of the Sucre Medical Institute, (2) meteorological documentary.

The author presents to the congress the following proposition relative to the Pan-American topic of Section II.

"Having in view the benefits and utilities that a detailed study of the atmospheric phenomena would bring to the nations of the South American Continent and to science in all its branches, and the convenience of verifying this study according to a scientific program for the progress of American meteorological science, the Second Pan-American Scientific Congress decide unanimously that each American Government that has not at present established a meteorological service should do so, provided with all the indispensable instruments for direct reading, and also of double registry apparatus of each one of the meteorological elements."

THE ORIGIN AND COURSE OF WEST INDIAN HURRICANES.

By JOSÉ CARLOS MILLÁS.

[Author's abstract.]

In this paper the results obtained by Father Viñes and the data of the recent investigations carried out by the meteorologic service of the United States are made use of in the study of the above topic. The author thus determines the regions most frequented by this class of cyclones. He points out the fact that there are several anomalies which indicate great variation in the causes and suggests that these variations be studied. The only definite statement the author makes in regard to the causes is that these storms have their origin in a parabolic zone which extends from the Cape Verde Islands to the Gulf of Mexico. He also notes that at the beginning of the hurricane period, the points of origin tend to be in the western part of the zone, while in the middle of the season, at the time of greatest frequency, the points of origin are more likely to be in the eastern part.

The author then takes up the problem of the origin and course of hurricanes. He says that from the theories that attempt to explain the formation of the phenomena arises the modern tendency to ascribe the initial moment of the cyclone to the dynamic hypothesis. He believes that many tropical storm phenomena are better explained by a modified hypothesis of condensation.

He calls attention to the solution proposed by Davis: Solar energy which gradually accumulates in the interior region of the atmosphere; the calm preceding the gyratory movement and the influence of the rotation of the earth. To these he adds the influence of opposing currents of different temperatures. He thinks that the opinion of Bigelow also must be considered. That the first movement of the whirl takes place in the upper strata in the zone between the high stratus and the cirrus.

From these considerations he draws the conclusion that the problem is far from being solved.

The author raises the following questions: (1) Does the gyratory movement descend or ascend? (2) If it ascends, does it always find suitable conditions for its development? (3) If it ascends, do the upper currents always provide the necessary elements for its development?

On taking up the course of hurricanes the author indicates what the normal path is in the different epochs and lays down practical rules to guide the observer. He considers also the forces which drive the storm in its parabolic course, one of which, the upper current, appears to have a special influence.

Finally he considers the course from the mathematical point of view, arriving at the conclusion that up to the present time the results of the studies made are more imaginary than real.

INVESTIGATIONS OF FORECASTS OF BAROMETRIC VARIATION.

By SIMÓN SARASOLA, S. J.

[Author's abstract.]

The author begins by establishing the fact that every rational forecast of the weather must depend upon a prediction of high and low pressure, since otherwise there can be no solid basis for a forecast. In the development of this proposition he reviews the different methods employed in the formulation of forecasts.

The author then turns to his personal investigations in this field. The periodicity of barometric variations may be studied from two points of view: (1) Examining the maximum and minimum pressures in a given locality to discover whether there really exists a periodic law by which it is possible to forecast the day on which the barometer will rise or fall; (2) studying the variations of pressure by means of the weather map over extensive regions.

The author believes that the forecasting of changes in atmospheric pressure may be made use of in relation to the hurricanes of the West Indies and he makes a brief reference to the isobaric method, formulating the following propositions: (1) "Atmospheric pressure suffers a periodical change. The approximate value of the period is 30 days; (2) the depressions, whether deep or not, appear periodically. The tendency to fall is noticed every 20 days." To prove these propositions the author gives a table of the most important hurricanes which have occurred from 1896 to 1915 in the West Indies, indicating the barometric readings in the Observatory of Belén in Habana.

The author says that it is possible to calculate when the barometer will fall, but not how much, and that on the day when this may be calculated with exactness the problem of barometric variations will be solved. He says that with his method he has been able to forecast with precision during the last 10 years the day on which the barometer would fall and when it would begin to rise. In this connection he refers to the cases published in the annals of the Observatory of Montserrat, No. 1, page 32.

The author next considers the method applied to the weather maps, especially those of Washington. He believes that the HIGH and LOW shown on these maps do not always indicate notable atmospheric disturbances, it being necessary many times to consider them in relation to the barometric reading of the nearest station; nor are they of special interest in the study of the depressions of some intensity. In his opinion the work of the Weather Bureau of the United States in the study of the course of cyclonic disturbances, their different types, etc., is very useful and helps to form an idea of the greater or less probability of the appearance of depressions in a given region.

ATMOSPHERIC ELECTRIC OBSERVATIONS ABOARD THE "CARNEGIE," 1915.

By W. F. G. SWANN.

[Author's abstract.]

This paper treats of the instrumental equipment and results of the observations made aboard the magnetic survey vessel, the *Carnegie*, of the department of terrestrial magnetism of the Carnegie Institution of Washington, during the portion of her 1915 cruise extending from Brooklyn to Alaska, via Panama and Honolulu.

The atmospheric-electric measurements aboard the *Carnegie* are as follows;

(1) The potential gradient.

(2) The conductivities λ_+ and λ_- arising from the positive and negative ions, respectively.

(3) The numbers of positive and negative ions per cubic centimeter (n_+ and n_-).

(4) The radioactive content of the atmosphere.

(5) The radioactive content of the sea water.

(6) The number of ions (R) produced per cubic centimeter per second in a closed vessel.

The following meteorological observations are made; Pressure, temperature, and humidity. The diurnal variations of the potential gradient, conductivity, and ionic content are also under investigation.

For potential-gradient measurements, the apparatus employed comprises a long brass tube, carrying a parasol attachment at one end, and mounted on insulated bearings fixed to the stern rail of the ship, so that it may be turned in a vertical plane containing the fore-and-aft line. Relative values of the potential gradient are obtained by measuring the alteration in potential which the insulated system undergoes when it is turned through a fixed angle from an earthed position.

For measuring the conductivity, the method of Gerdien, somewhat modified, is employed, and for measuring the ionic content a modification of Ebert's ion counter is used. The quantity R is obtained from the saturation current measured in a closed vessel, and the radioactive content is deduced from observations on the amount of active material collected in a given time when air is drawn through the space between two concentric cylinders, the central member of which is raised to a high negative potential.

The results for the Pacific Ocean are naturally the more interesting since here the vessel was on the average a considerable distance from land. The mean 9:30 a. m. value of the potential gradient over the Pacific Ocean is 116 volts per meter, while the mean value for the same time of day and year as obtained from nine land stations, is 149 volts per meter. The mean values of $n_+ + n_-$ and $\lambda_+ + \lambda_-$ are, respectively, 1,600 and 2.91×10^{-4} e. s. u., which are somewhat larger than the values 1,480 and 2.29×10^{-4} e. s. u. corresponding to the means for several land stations. The mobilities of the positive and negative ions are respectively 1.3 and 1.4 cms. per second per volt per cm.

The radioactive content of the air over the Pacific Ocean forms only about 2.5 per cent of the average value over land and is too small to be of any appreciable influence in determining the number of ions per c. c. The value of R for the Pacific Ocean is 3.9, and is more than sufficient to account for the observed ionization, but uncertainty must necessarily exist as to the portion of this amount attributable to the vessel itself.

The most striking feature presented by a comparison of the ionic content over land and sea is that the former is no greater than the latter in spite of the known extra cause for ionization to be found in the radioactive material in the former case. It is suggested that the greater rate of production of ions over the land is more than offset, as regards the measured ionic content, by the greater proportion of the ions which are there converted to the slowly moving, unmeasured type, by combination with dust nuclei.—*W. F. G. S.*

THE WEATHER AND CLIMATE OF SALT LAKE CITY, UTAH.

By ALFRED H. THIESSEN.

[Author's abstract.]

The climate of Salt Lake City, Utah, is interesting in many points—the relatively high annual mean temperature, mild winters, hot but agreeable summers.

Salt Lake City is 4,300 feet above sea level, protected by mountains on its north and east sides. The mean annual temperature is 51.7° F. The highest temperature ever observed was 102° and the lowest −20° During 41 years of records there were only 5 years when maximum

temperature rose above 100° and 14 years when the minimum temperature fell below 0°F.

The average temperature for the seasons is as follows: Winter, 31.6°; spring, 49.7°; summer, 72.3°; and fall, 52.5°.

January is the coldest month, with a mean temperature of 29.4°; but the lowest average monthly temperature is credited to February, 1903, which was 20°. The warmest month is July, whose mean is 75.4°.

There are 89 rainy days in Salt Lake City, and the average annual precipitation is 16.24 inches. The wettest year was 1875, when 23.04 inches were measured; the driest in 1890, 10.33 inches. April is normally the wettest month and July the driest. No excessive rainfall ever occurs in Salt Lake City. The greatest 24-hour amount was 2.72 inches, in May, 1901. The heaviest rain in one hour was 0.91 inch, on July 19, 1912. The average snowfall is 50.6 inches, most of which falls from December to March, inclusive.

In general, the climate is agreeable when one considers the effect of a year's experience. The warm summer days are accompanied by low humidities, followed by cool nights. The winter temperatures are sometimes quite low, but never for long periods.

CLIMATIC CONTROL OF CROPPING SYSTEMS AND FARM OPERATIONS

By J. F. VOORHEES.

[Author's abstract.]

The object of this paper is to prove that all successful cropping systems must be based on climatic conditions.

By cropping systems we refer to the number of crops that are grown successively on the same ground in one year, as a one-crop system or a two-crop system.

Climatic control may be positive or negative. Negative control is exercised when climate prevents us from growing more than a certain number of crops and when it permits us to grow a certain number of crops. Positive control is exercised when climate penalizes us for failure to grow as many crops as possible.

The climatic factors considered are rainfall, length of growing season, and heat intensity. Variations of these factors give us a great variety of climates, as the continuous-crop climate, the two-crop climate, the one-crop climate, and the no-crop climate.

Negative or preventive control is exercised in all but the continuous-crop climate, while positive control is exercised mainly in those regions where more than one crop can be grown.

Temperature controls our crop successions and our farm operations through control of the length of time required for the growth and maturity of both plant and insect life.

The penalty for failure to use a proper cropping system is loss of the farm. This is proved by the fact that many worn-out farms have been reclaimed by proper cropping systems.

To comply with the demands of climate more knowledge of the relationship between plants and animals on one side and climatic conditions on the other is needed. This knowledge can best be obtained through cooperation.

THE THUNDERSTORMS OF THE UNITED STATES AS CLIMATIC PHENOMENA.

By Prof. ROBERT DEC. WARD.

[Author's abstract.]

As essential characteristics of American climate, thunderstorms have a broad human interest. From the viewpoint of climatology, the distribution of thunderstorms is of more interest than their mechanism. The part played by their rains in watering our crops is of greater importance than the size of the raindrops. The damage done by their lightning and hail concerns us more than the cause of the lightning flash or than the origin of the hailstones. The thunderstorms of the eastern United States are among the most characteristic of American climatic phenomena. In size, intensity, and frequency of occurrence they are unique.

No part of the country is entirely free from thunderstorms, but the two regions of greatest activity are in Florida and in northern New Mexico. It is over the immense area east of the Rocky Mountains that our great State-wide thunderstorms occur, which often last for many hours, and may cover a territory stretching from the Mississippi Valley to the Atlantic coast. Throughout this area also, on hot summer afternoons, hundreds of scattering sporadic thunderstorms often occur, of local importance because supplying rain. These local storms are more frequent in southern than in northern sections, and as a whole the northern tier of States has distinctly fewer thunderstorms than the southern.

The thunderstorms of the mountains and plateaus of the West are chiefly sporadic and short-lived. They supply the rainfall of the higher elevations, commonly known as "islands" of rainfall, though obviously more appropriately termed "lakes." On the Pacific slope thunderstorms are not often experienced on the immediate coast, but occur more frequently in the interior valleys and on the mountains. They are characteristic summer phenomena at the greater elevations and furnish much or all of the "dry season" rainfall of those localities.

In relation to man's activities, it is of significance that most thunderstorms occur at the time of year and at hours when outdoor activities are at their height. The Southern States may be said to be in the thunderstorm belt all the year. As spring and summer come on, this belt moves northward. Taking the country as a whole, July brings most thunderstorms. Late spring and early summer bring considerable thunderstorm rainfall of marked economic importance over the eastern Rocky Mountain foothills and the Great Plains, while over the plateau region thunderstorms are most frequent in late summer. On the Pacific slope the inland thunderstorms show a preference for summer; the rarer ones of the immediate coast develop chiefly in winter.

A broadly generalized composite weather map is given, showing conditions under which "cyclonic" thunderstorms are likely to occur over the area from the Mississippi Valley eastward, and another map, also generalized, shows conditions favorable for the development of "heat" thunderstorms over the eastern United States.

Thunderstorms bring us much that is of benefit. To them we owe much, in parts of our country even most, of our spring and summer rainfall. Without these beneficent thunderstorms our great staple crops east of the Rocky Mountains would never reach maturity. One good thunderstorm over a considerable area at a critical crop stage is worth hundreds of thousands of dollars to American farmers. Our stock markets time and again show the favorable reaction of such conditions upon the prices of cereals and also of railroad and other stocks. Thundershowers break our summer droughts, cleanse our dusty air, refresh our parched earth, replenish our failing streams and brooks, bring us cool evenings and nights after sultry and oppressive days.

THE ECONOMIC ASPECT OF CLIMATOLOGY.

By EDWARD LANSING WELLS.

[Author's abstract.]

The economic status of the individual depends to a degree upon his environment and upon his ability to select a favorable environment or to make the most of that which is inevitable in his environment. Natural resources constitute a part of one's environment, and climate is an important natural resource.

Climate is intimately related to agriculture, engineering, transportation, commerce, manufacturing, health and efficiency, recreation, safety, and to practically every human activity.

It controls the distribution of vegetation, both as to kind and quantity, and successful agriculture depends upon a knowledge of climatology and how to make the best of existing conditions. Its relation to agriculture is indirect as well as direct, having to do with problems of irrigation, drainage, transportation, manufacturing, marketing, and the efficiency of labor, as well as with the control of insect pests and fungous diseases.

In engineering work climatology is of value in the development of water power and wind power, in the construction and maintenance of transmission lines, whether for power or for communication, in construction and operation of irrigation systems, in the construction of buildings, bridges, railroads, water-supply systems, sewers, and heating and refrigeration plants.

Few commodities are used where they are produced, and climatology enters largely into most of the problems of transportation. Sailing routes are laid out so as to take advantage of the great wind systems and to avoid storm tracks and fog areas. Floods, deep snows, high winds, etc., are to be considered in laying out railroads, and perishable freight must be protected in accordance with existing and expected weather conditions. Claims for damage to perishable freight and for car demurrage are often settled on the basis of weather records. Climate should be carefully considered in building and maintaining automobile roads.

The price of commodities, property, and labor depends to a certain extent upon supply and demand, and both supply and demand are affected by the climate. The prices of foodstuffs may vary rapidly under the influence of weather changes. Insurance rates are based, in part, upon the showing made by the weather records, and life insurance companies sometimes refuse policies to residents of States known to have an unhealthful climate. The distribution of many commodities, such as clothing and farming implements, is governed by the demands of the climate. Advertising, routing of salesmen, the location of distributing depots, and the pressing of collections depend upon weather conditions. The means of commercial communication are often good or bad, as the climate is favorable or unfavorable. In the storage of perishable products, studies of the climate are absolutely necessary. Conventions and fairs, having a commercial value to the localities where held, are attracted to places where the climate is known to be favorable.

Many manufacturing industries are regional because they demand certain climatological conditions. Among these may be mentioned the manufacture of tobacco products and textiles. The character of the

manufactured product is sometimes varied to suit the climate where the product is to be used, as in the case of prepared paints. Factories are sometimes located where water power may be obtained or where raw material is abundant, and both these conditions are peculiarly related to the climate.

Health and the personal attributes usually accompanying health all have an economic value, and these are dependent to a certain extent upon climate, either as climate affects the individual directly or as it brings about other conditions favorable or unfavorable for health. Often the climatological conditions affecting health are extremely local. The congregation of large numbers of health seekers in a region known to possess a healthful climate is a commercial asset to such a region. The efficiency of labor is reduced by a climate which is unfavorable for outdoor work.

Many forms of amusement and recreation have been commercialized, and of these a number are of such character as to group themselves naturally in certain climatological zones. Tourist travel is being deflected from its former lines and will be an increasing source of revenue to those sections known to have good scenery, good roads, and good climate. The industry of staging photoplays has become a regional one, owing to the favorable climate of certain sections.

There are certain meteorological phenomena that are much dreaded, and regions known to be free from these phenomena attract population because of such freedom. In such varied enterprises as the study of astronomy, the conservation and restoration of the forests, and the adjudication of cases at law, climatology plays a part, and in fact there is scarcely a human activity to which it is not related.

There are few lines of scientific investigation which promise greater return from an economic standpoint.

THE MEANING OF THE WORD "FAIR" IN METEOROLOGY.

By ELEANOR BUYNITZKY.

[Dated: Weather Bureau Library, Washington, Feb. 2, 1916.]

The meaning of the word "fair," as applied by meteorologists to weather conditions, has varied somewhat from time to time. In this country it was formerly used in recording the state of the sky, with reference to the degree of cloudiness. To-day, however, both in the United States and England, it is employed by meteorologists principally in connection with forecasts, to denote absence of precipitation.

The general dictionaries published in the United States have made some attempt to recognize the technical definitions of this term, as shown by the following quotations:

Century Dictionary.—Comparatively favorable or propitious; not obstructive or forbidding; moderately fit or suitable: as, *fair* weather (as distinguished from clear or foul weather). In the weather reports of the United States Signal Corps, the sky is said to be *fair* when it is from four-tenths to seven-tenths (inclusive) covered with clouds.—*Report of Chief Signal Officer for 1881, p. 745.*

New Standard Dictionary.—Having the sky from four- to seven-tenths covered with clouds: said of the weather, and distinguished from *clear*.

Webster's New International Dictionary.—Free from rain, hail, or snow; so used in the predictions issued by the United States Weather Bureau. The weather may be cloudy or threatening, but if no precipitation occurs it is called fair.

The old Signal Service definition found in both the Century and the Standard dictionaries has not been in official use since 1888, so far as the *regular* observers of the service are concerned, although the word "fair" in the sense "partly cloudy" was employed by *voluntary* observers until some years later. This was probably due to the fact that, for some unknown reason, the "Instructions for Voluntary Observers," published by the Weather Bureau in 1892, retained the old definition of the term, notwithstanding the fact that a Signal Service order had been issued four years earlier, substituting "partly cloudy" for "fair" in the various forms and reports of the service and stating specifically that "the term 'fair' will be construed in the Signal Service publications to mean absence of precipitation." (See list of definitions below.)

Reference is made to the official use of the word "fair" in the Report of the Chief Signal Officer for the year 1870, page 20, in connection with certain forms used by the "Division of Telegrams and Reports for the Benefit of Commerce." The term is not defined, but the context indicates that it was used to mean "partly cloudy" or "cloudy," without rain. A similar use of the word is also shown in the "Instructions to Observer Sergeants," Signal Service, 1871, page 15. Its history in the meteorological service of this country may be further traced in the following quotations taken from the "Instructions," etc., of the Signal Service and the Weather Bureau:

1875. U. S. Signal Service. Instructions to Observer Sergeants, 1875, p. 52:

In deciding whether a day is clear, fair, or cloudy, its character will be determined by taking the sum of the entire number of fourths of clouds observed at 7 a. m., 2 p. m., and 9 p. m. A clear day will be one in which the sum of the observed fourths is three or less than three; a fair day, one in which the sum is from four to eight, inclusive; and a cloudy day, one for which the sum is from nine to twelve, inclusive.

1881. U. S. Signal Service. Instructions to Observers, 1881 [replacing all former editions and amendatory orders up to and including June 14, 1881], p. 63:

The state of the weather will be determined as follows: *Clear*, when the sky is three-tenths or less than three-tenths covered with clouds; *fair*, when the sky is from four-tenths to seven-tenths (inclusive) covered; *cloudy*, when the sky is more than seven-tenths covered.

1881. U. S. Signal Service. Instructions to Special Observers in the Cotton Belt [published in connection with Signal Service Orders No. 55, July 14, 1881], p. 7:

In recording the state of the weather, at the time of observation, the following characterizations must be used:

"Clear," when the sky is less than one-fourth covered with clouds.

"Fair," "$\frac{1}{4}$ cloudy," "$\frac{2}{4}$ cloudy," and "$\frac{3}{4}$ cloudy," according to the amount of clouds observed at the time of observation.

"Cloudy," when the sky is more than three-fourths obscured by clouds.

1888. U. S. Signal Office. General Orders, No. 54, December 21, 1888, p. 1:

On and after January 1, 1889, the term "fair" will be construed in the Signal Service publications to mean absence of precipitation. The use of the word "fair," in the various forms and reports of the Service, to indicate partly cloudy weather will be discontinued and replaced by "partly cloudy."

1892. U. S. Weather Bureau. Office Instructions, No. 3, February 15, 1892 [effective January 1, 1892], p. 1:

Forecasts of fair weather will be considered to indicate the absence of rainfall in excess of 0.01 of an inch.

1892. U. S. Weather Bureau. Instructions to Voluntary Observers, by T. Russell, 1892, p. 60:

The weather is recorded clear when the sky is $\frac{1}{10}$ or less obscured; fair, when the sky is from $\frac{2}{10}$ to $\frac{7}{10}$ obscured; cloudy, when the sky is more than $\frac{7}{10}$ obscured; light rain (*lt. r.*), when there is light rain; [etc.].

1895. U. S. Weather Bureau. Instructions for Observers, 1895, p. 32:

In forecasting weather, the term "fair" is used to indicate that no precipitation in excess of 0.01 of an inch is anticipated.

1897. U. S. Weather Bureau. Instructions, No. 61, August 2, 1897, p. 2:

Forecasts of fair weather will be considered to indicate the absence of rainfall in excess of 0.01 of an inch.

1905. U. S. Weather Bureau. Station Regulations, 1905, paragraph 280:

Forecasts of "fair," "partly cloudy," or "cloudy" will be made when precipitation to the amount of 0.01 inch or more is not expected.

This was amended, October 1, 1905 (see Appendix to the 1905 Regulations, paragraph 8), to read as follows:

Forecasts of fair weather will be verified when precipitation in excess of 0.01 of an inch does not occur.

1915. U. S. Weather Bureau. Station Regulations, 1915, paragraph 425:

Forecasts of "fair," "partly cloudy," or "cloudy" will be made when precipitation to the amount of 0.01 inch or more is not expected.

In England, the term "fair" as used by meteorologists has much the same meaning that it has in the United States. Murray's New English Dictionary contains the following definition:

Of the weather. Favourable, not wet or stormy. Also with some notion of sense I [beautiful]: Fine, bright, sunny. Now sometimes contrasted with *fine*, as "the weather was fair, but not fine."

British official usage in this connection is described in a letter from the Director of the Meteorological Office, London, dated December 2, 1915, as follows:

I am in receipt of your letter of November 12th, asking whether the terms "fair" and "fine" have ever been officially defined by this Office.

No official definitions have been put forward, but the words have come to be used fairly regularly in our forecasts.

Both would only be applied to a day or an interval during which there was no precipitation. In using the word "fine" the forecaster has in mind a period over which the weather can be described by the Beaufort letters "b" or "bc," while "fair" would apply to an interval to which the Beaufort letters "bc" and "c" would be applicable, but I do not think anyone would quarrel with the use of the word "fine" to describe a period during which the sky was covered by a veil of high cloud, say, of the cirro-stratus type, even if technically the cloud amount might be represented by the figure 10 or by the Beaufort letter "o."

[The Beaufort letters referred to are officially defined by the British Meteorological Office as follows: b=blue sky, cloudless; bc=a combination of blue sky with detached clouds; c=sky mainly cloudy but with openings between the clouds; o=completely overcast.]

THE AURELIA ALTO-CUMULUS CLOUD.

By GEORGE REEDER, Section Director.

[Dated: Weather Bureau, Columbia, Mo., June 27, 1914.]

The accompanying rough sketch that I made in Columbia, Mo., at about 8:30 a. m., June 25, 1914, shows an interesting and unusual cloud formation. I do not own a camera, otherwise I would have photographed them; and, it goes without saying, I am a poor sketch artist. I have named the cloud "Aurelia" because each time (this being the third) I have observed them my thoughts instantly flashed to the jellyfish (*Cyanea arctica*), called "stinging nettle" by some southern fishermen.

This cloud formation, so far as my own observations go, seems characteristic of the Middle West or semiarid regions. I never observed a similar formation in other parts of the country during former years. Twice these clouds were seen in the southern part of the sky, and once in the north, rather low down. Each time, though, it was during periods of prolonged drought, and the formation was the same, i. e., alto-cumuli drifting slowly eastward, with long underneath streamers of hairlike texture, bent backward toward the west.

Presumably, then, this form of cloud is the result of two currents of air, flowing in opposite directions. In other words, the alto-cumuli float on eastward until they meet and enter the current coming from the east, which is, without doubt, a dry, descending one. The cumuli then soon begin to disintegrate and evaporate, small particles

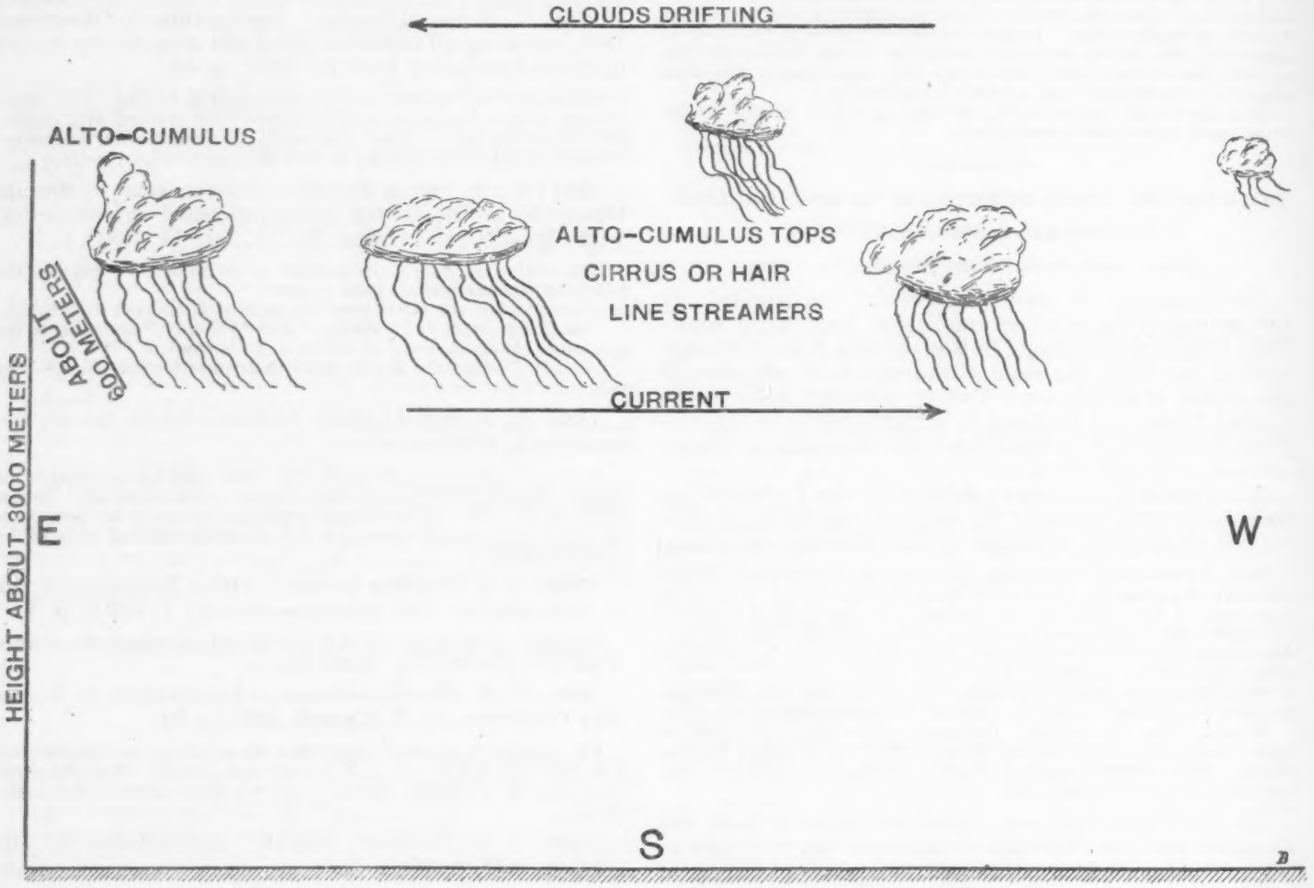

FIG. 1.—Peculiar form of alto-cumulus observed by Geo. Reeder at Columbia, Mo., 8:30 a. m., June 25, 1914.

of cloud being carried down in streamers, which in turn soon disappear. In fact, these clouds, streamers and all, disappear by evaporation in about 30 to 40 minutes after the descending movement begins.

TORNADOES IN KANSAS.

By S. D. FLORA, Observer, U. S. Weather Bureau.

[Dated: Weather Bureau, Topeka, Kans., Dec. 18, 1915.]

Kansas has been so commonly considered the tornado State of the country that the term "Kansas cyclone" has almost become a part of the spoken English language, but this idea is as misleading as the use of the word "cyclone" to designate what should properly be called a *tornado*, that is, an exceedingly violent whirling storm of small diameter, with a pendant, funnel-shaped cloud.

It seems that a large part of this undesirable reputation of the State has been the result of undue publicity given such spectacular storms by the early settlers and continued by the activities of later disseminators of news.

That tornadoes do occur in the State practically every year and sometimes several within the same year can not be denied, but it should be considered that, while the area of the State exceeds 80,000 square miles, the path of an average tornado does not cover more than 25 square miles and many are a great deal smaller, so that one can generally be represented by a pin scratch less than an inch long on a map of the State of the size usually given in an atlas.

In a report on tornadoes of the United States for the eight years, 1889–1896, which is the most complete of the kind published, Prof. A. J. Henry [1] of the Weather Bureau has published data indicating that the total number of tornadoes in Kansas is somewhat greater than the number in any other State. When the relative areas are considered, however, the number of tornadoes in Kansas per unit area is practically the same as the corresponding number for Iowa and is but slightly greater than the number for Illinois, yet neither of these States has Kansas's reputation of being a tornado State. Prof. Henry in the same report has also deduced that even in the States where such storms occur most frequently "the probability that any area 100 miles square will be visited by a tornado in any year is generally less than certainty," and further, "for any specific area or farm of 1 square mile the probability [of being visited by a tornado] is less than one-sixteenth of 1 per cent per century." [2]

During the 10 years, 1889–1896 and 1914–15, for which definite information regarding the destruction by tornadoes is available, the average annual number of deaths in Kansas directly due to these storms is 14, or less than the number of deaths by lightning as shown by the mortality statistics of the State Board of Health, and much less than the number caused by any disease of common occurrence in the State. The average property loss for the period, even though it was almost doubled by the recent tornado at Great Bend, is insignificant when compared with the total wealth of the State or the annual losses by flood and hail, yet neither of these has attracted the notice given the damage inflicted by tornadoes.

The months of greatest frequency of tornadoes in the State are indicated by Table 1 compiled from the report of Lieut. John P. Finley [3] covering the years 1859–1887, the report of Prof. A. J. Henry covering the period 1889–1896, and the monthly reports of the Kansas section for the years 1914 and 1915.

TABLE 1.—*Total number of tornadoes, by months, reported in Kansas, 1859–1887, 1889–1896, 1914–15.*

January	0
February	1
March	16
April	41
May	66
June	54
July	20
August	15
September	8
October	3
November	4
December	0
Entire period	228

With the present available data it is idle to speculate whether any part of the State is more likely to be visited by these storms than any other part. The report of Lieut. Finley, while it covers a long period of time, is admittedly incomplete, being obtained "from all available sources" years after many of the storms had occurred, which means that many tornadoes might have occurred in sparsely settled communities during the early part of the record without having been reported; the report of Prof. Henry and those of the years 1914–15 cover too short a period to shed much light on this question.

Present knowledge of the cause of these storms discredits the idea that their formation is favored or hindered by such slight differences in topography as exist in a State as comparatively level as Kansas. Also there is no reason to believe they are becoming any more or less frequent than formerly. It is probable losses due to their destructive effects will increase as the land becomes more thickly settled, but not necessarily in proportion to the total population and wealth of the State.

The following Tables 2, 3, and 4 give a record of tornadoes in Kansas for all the years for which data are at present available.

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[1] Tornadoes, 1895-96, by Alfred J. Henry, p. xxiii-xl, charts I-VIII. (Report of the Chief of the Weather Bureau, 1895-96. Washington, 1896. 4°.)

[2] See also *Abbe, C.*—Tornado frequency per unit area, this REVIEW, June, 1897, p. 250.—EDITOR.

[3] *Finley, John P.* The tornadoes of Kansas for 29 years, 1859-1887. J. H. Soulé, Washington, 1888. n. p. map. 16½ cm.

TABLE 2.—*List of tornadoes reported in Kansas, 1859–1887.*

[From the report of Lieut. John P. Finley, U. S. Signal Corps.]

County.	Date.	Time.
	1859.	
Franklin and Miami	June —	3 a. m.
Ottawa	June 20	Afternoon.
	1860.	
Doniphan	July 4	5 p. m.
Shawnee	July 31	5 p. m.
Marshall	July 31	3:30 p. m.
	1863.	
Doniphan	June 16	Afternoon.
	1870.	
Republic	Nov. 8	Afternoon.
	1872.	
Saline	April —	
	1873.	
Cloud	June 28	3 p. m.
	1874.	
Osage	Apr. 4	
Butler	June 22	Afternoon.
Montgomery	June 26	Afternoon.
	1876.	
Pawnee	Mar. 5	
Ford	Apr. 26	
Leavenworth	May 6	3:15 a. m.
Ford	May 13	
Saline	June 6	3:30 p. m.
Do	June 6	Afternoon.
Do	June 6	Afternoon.
Lincoln	June 6	Afternoon.
Saline	June 7	2:45 p. m.
Do	June 12	
Ford	June 13	
Bourbon	June 15	
	1877.	
Ford	Apr. 22	Afternoon.
Ottawa	May 18	Afternoon.
Saline	May 18	Afternoon.
Cloud	June 12	Afternoon.
Leavenworth	Aug. 25	Afternoon.
	1878.	
Cherokee	Mar. 1	5 p. m.
Marshall	Apr. 5	5 p. m.
Chase	Apr. 13	Afternoon.
Leavenworth	Apr. 17	Afternoon.
Leavenworth and Jefferson	May 25	4 p. m.
Marshall	May 31	5:30 p. m.
	1879.	
Brown	May 29	6 p. m.
Ottawa	May 30	3 p. m.
Do	May 30	3 p. m.
Marshall	May 30	6:30 p. m.
Do	May 30	5:30 p. m.
Ellsworth and Lincoln	May 30	2:30 p. m.
Riley	May 30	6 p. m.
Ottawa	May 30	4 p. m.
Clay	May 30	5:30 p. m.
Cloud	May 30	3:30 p. m.
Saline	June —	6 p. m.
Ottawa	June 10	Evening.
Mitchell	June 10	Afternoon.
Leavenworth	June 10	Afternoon.
Douglas	June 10	5 p. m.
Cloud	June 12	Afternoon.
Stafford	July 28	
	1880.	
Cherokee	Apr. —	
Franklin	Apr. 2	6 p. m.
Crawford	Apr. 2	7 p. m.
Johnson	Apr. 18	4:30 p. m.
Woodson	May 9	5 p. m.
Ness	May 19	3 p. m.
Saline	June 5	
Lane	Aug. 15	3 p. m.
	1881.	
Smith	Mar. 10	4:15 p. m.
Cherokee	Mar. 16	Forenoon.
Do	Apr. 1	12:10 p. m.
Chase	Apr. 30	6 p. m.
Clay	May 13	Afternoon.
Woodson	May 16	
Lane	June 7	3 p. m.
Osborne	June 9	5:30 p. m.
Morris	June 9	5 p. m.
Ottawa and Dickinson	June 9	5 p. m.
Mitchell	June 9	4 p. m.
Lyon	June 11	4 p. m.
Sumner	June 12	4 p. m.
Osage	June 12	5 p. m.
Cowley	June 12	4:30 p. m.
Lyon and Osage	June 12	4 p. m.
Saline	Sept. 1	4 p. m.

County.	Date.	Time.
	1881.	
Sumner	Sept. 29	Afternoon.
Riley	Sept. 29	6 p. m.
Nemaha	Sept. 29	6 p. m.
Dickinson	Sept. 29	About noon.
Lyon and Woodson	Sept. 29	6:30 p. m.
	1882.	
Stafford and Rice	Apr. 5	4 p. m.
Saline	Apr. 5	5:50 p. m.
Reno	Apr. 5	4 p. m.
Clay	Apr. 6	5 p. m.
Butler	Apr. 7	10:30 p. m.
Crawford	May 12	
Linn	June 7	4 p. m.
Anderson	June 14	3 p. m.
Greenwood	July 16	Morning.
Shawnee	Aug. 6	10:40 a. m.
Russell	Aug. 27	10:35 p. m.
	1883.	
Wabaunsee	Apr. 19	Night.
Barber	Apr. 27	11:30 p. m.
Doniphan	May 13	
Wyandotte and Johnson	May 13	4:30 p. m.
Labette and Cherokee	May 13	6 p. m.
Riley and Pottawatomie	June 11	10:25 p. m.
Jefferson	June 11	11:30 p. m.
Jackson	July 10	10 a. m.
Do	July 10	10 a. m.
Sumner	July 16	5 p. m.
Decatur	Aug. 14	About 3:30 p.m.
	1884.	
Anderson	Apr. 26	4 p. m.
Phillips and Smith	Apr. 26	2 p. m.
Pawnee	Apr. 28	9 p. m.
Russell	Apr. 28	5:15 p. m.
Montgomery	May 20	3:15 p. m.
Russell	May 30	4 p. m.
Jewell	June 14	
Do	July 12	
Barton	July 18	8:45 p. m.
Jewell	July 20	
Russell	July 26	7:15 p. m.
Scott, Lane, Hodgeman, Ford	July 26	7:15 p. m.
Shawnee	Aug. 24	
Montgomery	Sept. 26	
	1885.	
Rice	Apr. 21	2 a. m.
Mitchell	Apr. 29	4 p. m.
Rooks	May 15	4 p. m.
Kingman	May 15	5 p. m.
Phillips	May 16	4 p. m.
Kingman	May 16	6 p. m.
Nemaha	May 27	11:30 a. m.
Marshall	May 27	10:40 a. m.
Jackson	May 27	12 m.
Jefferson	May 27	12:15 p. m.
Atchison	May 27	12:30 p. m.
Kingman	June 19	1 a. m.
Leavenworth	June 20	Night.
Stafford	June 20	Evening.
Do	July 1	3 p. m.
Jewell	July 26	5 p. m.
Atchison	Aug. 5	1:25 p. m.
	1886.	
Nemaha	Apr. 14	Night.
Do	Apr. 14	4 p. m.
Jackson	Apr. 14	4 p. m.
Saline	Apr. 22	Afternoon.
Neosho	May 6	2 p. m.
Lyon	May 6	Afternoon.
Barton	May 6	Afternoon.
Neosho	May 6	4 p. m.
Jefferson	May 9	Afternoon.
Do	May 11	11 a. m.
Atchison	May 11	10:30 a. m.
Do	May 11	11:45 a. m.
Jefferson	May 14	10 a. m.
Russell	May 25	Afternoon.
Reno	July 19	6 p. m.
Finney	July 19	5 p. m.
Hamilton	Aug. 15	Evening.
	1887.	
Jewell	Feb. 17	2 p. m.
Linn	Apr. 21	5:30 p. m.
Atchison	Apr. 22	2:30 p. m.
Woodson	Apr. 22	Morning.
Anderson	May 16	2 p. m.
Clay	May 22	6:15 p. m.
Lyon	July 19	4 p. m.
Shawnee	July 21	8:40 p. m.
Graham	Aug. 4	8 p. m.
Jefferson	Aug. 4	5 p. m.
Pottawatomie	Aug. 4	5 p. m.
Cherokee	Aug. 10	6 p. m.

TABLE 3.—*List of tornadoes reported in Kansas, 1889–1896.*

From report by Prof. A. J. Henry, *in* "Report of the Chief of the Weather Bureau 1895–96."]

County.	Date.	Hour.	Loss.	
			Lives.	Property.
	1889.			
Pratt	May 6	6 p. m.		
Stafford	May 6	7:30 p. m.		
Rice	May 6	8:15 p. m.	†3	†$8,000
Washington	May 6	11:20 p. m.	0	4,000
McPherson	May 28	2 p. m.	0	2,500
Chase	May 28	4 p. m.	1	8,000
Chautauqua	June 8	2 p. m.	0	6,000
	1890.			
Wilson	May 9	4 p. m.	2	Unknown.
	1891.			
Decatur	May 20	12:30 a. m.	0	7,500
	1892.			
Kiowa	Mar. 31	8:30 p. m.	0	15,000
Rice	Mar. 31	5:30 p. m.		
Saline	Mar. 31	6:30 p. m.		
Clay	Mar. 31	8 p. m.	†2	†12,000
Sumner	Mar. 31	8 p. m.		
Sumner	Mar. 31	9 p. m.		
Butler	Mar. 31	9:30 p. m.		
Butler	Mar. 31	10 p. m.	†17	†18,000
Marion	Mar. 31	10 p. m.		
Chase	Mar. 31	11 p. m.		
Pottawatomie	Mar. 31	Midnight.	†11	†25,000
Montgomery	Apr. 3	2:30 p. m.	1	(*)
Greenwood	May 13	6:50 p. m.	0	1,500
Harper and Sumner	May 27	6:30 to 9 p. m.	16	300,000
	1893.			
Linn	Apr. 11	5:30 p. m.	0	100,000
Brown	Apr. 11	4:05 p. m.	1	5,000
Osage	Apr. 12	4:30 p. m.	1	12,000
Miami	Apr. 12	7:30 p. m.	0	500
Anderson	Apr. 28	5:30 p. m.	1	1,000
Jefferson	June 21	6:30 p. m.	10	2,000
Cowley	June 21	8 p. m.	0	25,000
Pawnee	Aug. 10			1,000
Logan	Aug. 12	2 p. m.	2	1,500
	1894.			
Jewell	May 2	5:45 p. m.	0	4,000
Chase	June 25	5 p. m.	0	5,000
	1895.			
Crawford	Apr. 15	7 p. m.	1	10,000
Harvey	May 1	4:30 p. m.	8	70,000
Lyon	June 17	5:30 p. m.		15,000
Coffey	Sept. 8	3 p. m.		25,000
	1896.§			
Cloud, Clay, and Washington	Apr. 20	9 to 9:30 p. m.	8	15,000
Rice	May 11	6 p. m.	0	(*)
McPherson	May 15	4 a. m.	1	1,000
Washington, Marshall, Nemaha, and Brown.	May 17	4:30 to 8:30 p. m.	†25	†300,000
Cowley	May 19	4 p. m.	0	3,000
Lyon	May 20	8 p. m.	0	500
Shawnee	May 20	5 p. m.	0	2,500
Cowley	May 20	11 a. m.	0	200

† This includes totals for storms immediately preceding for which no total is given.
* Damage very small.
§ To June 30 only.

TABLE 4.—*List of tornadoes reported in Kansas, 1914 and 1915.*

[From "Monthly Reports of Climatological Data of Kansas."]

County.	Date.	Hour.	Loss.	
			Lives.	Property (estimated).
	1914.			
Rice	Mar. 28	5:30 p. m.	0	$85,000
Sumner	Apr. 17	5:30 p. m.	2	100,000
Butler	June 1		0	(*)
Smith	June 2	6:15 p. m.	0	(*)
Bourbon	Aug. 19	3 p. m.	0	(*)
Wilson, Neosho, and Greenwood#.	Oct. 9	5:30 to 6:30 p. m.		
Montgomery and Labette	Oct. 9	7:30 p. m.		
Cherokee	Oct. 9	8 p. m.	†10	†50,000
	1915.			
Wichita	June 3	6 p. m.	1	40,000
Kiowa	June 11	6:30 p. m.	0	60,000
Pottawatomie	June 17	4 p. m.	5	5,000
Coffey	June 17	5 p. m.	0	40,000
Bourbon	June 17	9 p. m.	0	50,000
Grant	June 23	3 p. m.	0	(*)
Crawford	June 30		0	2,000
Barton	Nov. 10	7:07 p. m.	11	1,000,000
Pratt	Nov. 10	8:30 p. m.	0	15,000
Sumner and Sedgwick	Nov. 10	10 p. m.	3	50,000

* Damage very small.
# Three tornadoes in succession in practically the same path.
† This includes totals for storms immediately preceding for which no total is given.

Total number of tornadoes in the 10 years 1889–1896 and 1914–15, 64; number of lives lost, 143; property loss, $2,427,200.

REFORESTATION AND OCCULT CONDENSATION.[1]

By PAUL DESCOMBES, Honorary Director of State Manufactures.

[Dated: July 28, 1914, Bordeaux, France.]

The tree has always been considered the great regulator of waters, although science has yet to translate this beneficent action into precise formulæ. There are periods when one sees entire regions laid waste by deforestation, as Algiers where the aqueducts and the hot springs of ancient cities contrast with the dried-up beds of wadies which watered them in former times, and it is only a few years since man began to penetrate the mystery which envelops the hydrologic rôle of the forest.

From the very first investigations have supported an increase of rains by reforestation, and M. Daubrée summarized them in 1910 in his report to the Commission on Floods, as follows:

The condensing action of forests has been confirmed experimentally at l'École de Nancy. From a series of observations made in 1867–1899 it follows that the average quantities of rain falling in a forest and outside a forest are in the ratio of 100 to 76. Prof. Ebermayer in Germany and Blanford in India have found that the depth of rainfall has been, on the average, 12 per cent greater in a forest than on an open field.

The action of forests upon rain should not be relegated to the infinitely small meteorological data, as Cézanne says. One is justified in asserting that the presence of forests augments pluviosity, to be sure in variable measure, according to the air currents, topography, and from other causes.[2]

This increase of the annual amount of rain water, whether it be a quarter or an eighth, is far from corresponding to the amplitude of the phenomenon which transforms regions previously watered but from which the tree has disappeared, into waterless deserts, and a new way opened up to investigations when attention was drawn to the importance of atmospheric condensations not measurable by the raingage.

The majority of the works on forestry emphasize the influence of the forests upon the rainfall régime and the regulation of run-off. The trees have yet another hydrologic rôle which it is proper to put in evidence—they provoke an abundant condensation of meteoric water without rain.

In foggy weather everyone has seen numerous drops fall from the trees resulting from the condensation of the fog.

In the clearest air, also, abundant condensation is produced on the trees; dew during the night, hoarfrost and needles of all forms during days of frost.

All waters resulting from these condensations without rain reach the ground softly and successively, under the most favorable conditions for their absorption by the soil and the nourishing of springs. They are of great interest in alpine economy because they always contain ammonia even at the highest elevations and thus supply nitrogen assimilable by vegetation. In the equatorial regions, even far removed from the sea and permanent water bodies, the dew continues to form during the dry season and is abundant enough to support vegetation and to furnish water to certain animals.[3]

These diverse varieties of condensation without rain occur also on the bare soil, but their intensity is found to be considerably augmented in the forests by the expanse and high radiative power of the foliage surface.

The determinations which one might make in cold regions or at great altitudes would present a very real interest in making known the importance of these condensations without rain and the relations which they might bear to the quantity of water evaporated by the vegetation.[4]

[1] *Descombes, Paul.* Le réboisement et les condensations occultes. C.-r. Assoc. franc p. l'avancem. des sci., 43me sess. Le Havre, 1914. Notes et Mém. Paris, 1915. pp. 337–341 *Translated by* H. Lyman and C. Abbe, jr., for the MONTHLY WEATHER REVIEW.

[2] *Daubrée, L.* Rapports et documents de la Commission des Inondations. Imprimerie Nationale, Paris, 1910, p. 506.

[3] Reported by *Henri Polier,* Captaine de l'Infanterie coloniale.

[4] *Descombes, Paul.* Sur un mode de l'action hydrologique des fôrets. Soc. des. sci. phys. et nat., Bordeaux, 17 mars 1904.

French experiments in this line have not yet been possible, for the service of agricultural meteorology has been established only a few months in France and the decree prepared two years ago [1912] looking toward the organization of a scientific forest service has not yet been signed. Still, some recent results make it possible to estimate the importance of condensation without rain.

It is known in effect that the Swiss meteorologists, particularly Prof. Forel, have reported an unlooked-for circumstance which is often manifest at great altitudes, viz, the annual stream discharges exceed the amount of rain or snow falling in the valley and measured instrumentally;[5] furthermore, the same has been observed in France on the plateau of Langres, at the reservoir of the Mouche which serves to feed the canal between the Marne and the Meuse. These supplemental waters arising from condensations without rain, one may conclude that in certain drainage basins the quantity of water originating from occult condensations exceeds that lost by evaporation, and since, according to M. Daubrée, the amount of evaporation from a drainage basin is more than half of that which falls as rain,[6] these occult condensations exceed in certain cases one-half of the rain received by the valley.

If it is not yet known by precise measurements the degree to which reforestation augments these occult condensations, it suffices to compare the plumes of hoarfrost which decorate a tree after a clear winter night or the large drops which in the morning roll about on the leaves of the humble cabbage, with the extremely small quantity of dew that covers an equivalent area of denuded soil in their neighborhood in order to perceive that vegetation considerably augments these occult condensations.

Lacking the experiments in observatories or research laboratories—not a specimen of which has been so far published—a preliminary determination permits one to appreciate the degree to which vegetation may reenforce this occult condensation.

The amount of dew collected on May 2, 1913, on some carefully measured leaves amounted to 2.3 grams per square decimeter, which corresponds to 0.23 mm. of rainfall. Now, assuming that the foliage of a large tree represents but 15 stages of leaves and that the number of nights when the dew forms on them may be 200 per year, a not improbable number in a dry climate, then the water annually deposited would be the equivalent of $0.23 \times 15 \times 200 = 690$ mm. This quantity of water differs but little from the annual rainfall at a great number of stations, and we are justified in saying that "the quantity of water annually deposited on the trees by occult condensation is of the same order as that coming from rains."

The importance of this supplementary supply of meteoric water for the wooded terrain shows how the destruction of forests helps to transform it into desert soil. Deforestation, first of all, cuts down the major part of occult condensations and at the same time reduces the quantity of rain water. It is generally followed by increased pasturing of goats and sheep, whose short-sighted owners believe that more grass will be secured by cutting down the woods, and the live stock devour down to the roots the plants that they tear up while browsing in dry seasons.

When the herbaceous vegetation, increasingly rare, has disappeared in its turn, the burning sun rapidly evaporates all the surficial waters while the subterranean rivers exist only for the purpose of carrying off the waters precipitated by the steadily decreasing and intermittent rains.

This is the kind of devastation that causes such an encroachment of the desert as was recently reported by the expedition to survey the region about Lake Tchad:

> A series of dry years—says the commander, Tilho—has permitted the Sahara to advance southward at the same time that Lake Tchad diminished in extent. Thus, in July, 1908, the oasis of Beduaram to the north of Lake Tchad marked the boundary between steppe and desert; its arborescent vegetation fell off to some 10 or 12 Talhas, and the dune on the southeast was covered with the characteristic desert plants—Had and Nessi. Now in June, 1870, Nachtigal had noted in the same region the absence of Had and the existence of a thin forest (une claire forêt) composed of trees of the Soudan steppe. In 1908, at the time of our visit, the first gum acacias and a few Serrahs did not appear until we were well within the depths of the oasis N'Gourti, more than 60 kilometers south of Beduaram.[7]

The *Acacia tortilis*, the Talha, which the Lake Tchad expedition photographed near the Gouradi wells,[8] is the sole survivor of an immense forest whose history we shall never know. Besides it will never matter whether the forest was destroyed by fire or otherwise, the climatic modifications that have accompanied its disappearance show the genesis of the transformation into desert.

The manner in which the desert spreads and by which the climatic deterioration is aggravated suffice, furthermore, to indicate the countermethods for the rescue of certain desert regions from the vicious circle in which they seem to be at a standstill. "Vegetation is lacking for want of water and water is lacking for want of vegetation."

It would generally be possible to reestablish in the vicinity of wells or oases any kind of vegetation merely by suppressing pasturage, and this would result in a first hydrologic amelioration. The trees which could then be planted in the shelter of the initial vegetation would produce a further improvement in climate, and the progressive enlargement of these spots of verdure would thus reclaim considerable regions from the desert.

Furthermore, it is not necessary to go as far as the desert in order to appreciate the interest which attaches to the reenforcement by occult condensations, for it would remedy the scarcity of water under which navigation and hydraulic power suffer during the summer in the majority of our rivers.

The forestry research stations should not delay in informing us of the amount of dew deposited in various forms on trees of varied species and dimensions, and upon the importance of occult condensations during different periods of the year. These determinations which, of course, present certain difficulties, might keep us waiting a long time, as also the results of the observations made outside the laboratories, in the field itself, under various conditions of forestation, and it would be a very great lack of foresight to put off for so long a time a serious effort toward reforestation.

While working energetically toward reforestation it is well, however, not to forget the theoretical researches, and we present the following resolution:

"That studies be undertaken on the supplementary contingent of the waters which reforestation brings to the soil by reenforcing of occult condensations."

[5] Service d'études des grand forces hydrauliques, région des Alps. Paris, 1908, tome iii, p. 22.
[6] Daubrée ,L., loc. cit.
[7] *Ministère des colonies*, Documents sci. de la mission Tilho. Paris ,1911, t. 2, p. 10 bis.
[8] Mission Tilho, loc. cit., p. 45.

PERCENTAGE FREQUENCY OF THUNDERSTORMS IN THE UNITED STATES, 1904-1913.

In the REVIEW for July, 1915, Mr. William H. Alexander presented a set of tables showing the total numbers of thunderstorms observed and recorded at the Weather Bureau stations from the beginning of observations to 1913, inclusive. Absolute numbers do not show as clearly as do relative numbers the seasonal distribution of such phenomena; therefore Mr. Herbert Lyman has prepared the following table of percentages showing thunderstorm frequencies for the different months on the basis of the fairly uniform series of observations between 1904 and 1913, both inclusive.

The average character of the seasonal distribution of thunderstorms in the United States appears from the following figures showing the number of stations whose maximum monthly percentage of thunderstorms falls in the respective months.

Month.	Number of stations.
January	1
February	0
March	3
April	0
May	6
June	33
July	78
August	15
September	2
October	0
November	0
December	2

From these figures it appears that practically all the Weather Bureau stations have their maximum number of thunderstorms during the summer months June to August. Such stations may be called the *regular type*, for purposes of classification. This table also shows that there are a number of stations where the maximum percentages fall in the winter months. Table 1 will show that most of these nonregular stations have two maxima, but a minimum in July or August. Among them may be mentioned Fresno, Los Angeles, and Sacramento. Port Crescent is peculiar in having its prime maximum in July with a secondary maximum in December, while Red Bluff departs from the other Pacific coast localities in having its prime maximum in May and its secondary maximum in October.

There are three of our stations, however, which show a well-defined simple curve of frequency which is just the opposite of the regular type curve. It may be called the *inverted type* curve, and the stations are Eureka and San Francisco in California and Honolulu, Territory of Hawaii. Eureka has a tendency to depart from the type slightly, and San Francisco has so few thunderstorms—eight in 10 years—that it does not give a very strong curve. Honolulu seems to be the best-established representative of this inverted type in the United States' possessions. Its minimum sinks to zero in July and August and rises to 21 per cent for both December and January.

We might make a more detailed analysis of the distribution of thunderstorms, but prefer to wait for another 10 years of homogeneous records. Enough is brought out here to show that over most of the United States the thunderstorm frequency is closely related to the temperature march.

TABLE 1.—*Percentage of thunderstorm frequency for the 10-year period 1904–1913.*

[Computed to nearest whole number.]

Stations.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Storms in 10 years.
	%	%	%	%	%	%	%	%	%	%	%	%	
Abilene, Tex.	2	2	5	11	19	12	17	13	9	6	3	1	339
Amarillo, Tex.	0	1	3	9	17	18	19	19	9	3	2	0	356
Atlanta, Ga.	1	2	6	6	12	17	24	21	9	1	1	0	626
Atlantic City, N. J.	0	2	5	11	12	18	21	18	8	5	1	1	286
Augusta, Ga.	1	3	6	6	11	18	24	20	9	2	2	1	532
Baker, Oreg.	0	0	0	4	12	28	23	16	12	2	0	0	171
Baltimore, Md.	1	2	6	9	14	17	26	16	8	2	0	0	325
Bismarck, N. Dak.	0	0	0	4	15	24	23	23	9	4	0	0	285
Block Island, R. I.	1	3	7	11	12	14	21	16	10	4	3	0	193
Boston, Mass.	2	1	4	4	14	17	23	22	11	2	2	1	180
Buffalo, N. Y.	1	1	5	5	16	17	22	18	10	4	2	0	315
Charleston, S. C.	1	4	4	7	10	16	22	20	12	2	2	1	634
Charlotte, N. C.	1	2	4	7	12	21	25	19	7	2	1	0	518
Chattanooga, Tenn.	1	3	6	7	11	20	20	19	11	1	2	1	681
Cheyenne, Wyo.	0	0	0	5	14	23	27	21	9	1	0	0	528
Chicago, Ill.	2	1	6	8	15	16	17	16	12	4	2	0	400
Cincinnati, Ohio.	1	1	5	8	15	19	22	14	10	3	2	0	456
Cleveland, Ohio.	1	1	4	8	16	17	22	16	11	5	1	0	384
Columbia, Mo.	2	2	6	9	14	17	16	16	10	4	4	1	575
Columbia, S. C.	2	2	5	7	12	19	22	21	8	2	1	1	544
Columbus, Ohio.	2	1	6	8	14	18	22	15	10	2	2	0	456
Concordia, Kans.	0	1	3	7	15	21	19	17	13	4	1	0	455
Corpus Christi, Tex.	0	3	6	11	18	10	13	13	17	4	3	3	304
Davenport, Iowa.	1	1	5	7	15	17	17	19	13	4	2	0	462
Denver, Colo.	0	0	2	3	14	21	26	23	11	1	0	0	467
Des Moines, Iowa.	0	1	4	8	16	18	18	16	12	7	1	0	509
Detroit, Mich.	2	2	4	9	14	17	21	16	10	5	2	0	365
Dodge City, Kans.	0	0	2	6	14	22	22	18	10	4	2	1	399
Dubuque, Iowa.	0	0	4	8	14	18	18	18	13	5	2	0	416
Duluth, Minn.	0	0	1	3	14	21	28	18	12	3	0	0	282
El Paso, Tex.	1	2	1	3	4	14	27	32	10	6	1	0	328
Erie, Pa.	1	1	5	6	14	19	18	16	12	6	1	1	368
Eureka, Cal.	12	12	22	4	0	0	6	0	6	12	4	24	33
Fort Smith, Ark.	3	3	6	11	16	18	13	15	9	4	3	0	559
Fresno, Cal.	3	14	16	14	16	5	3	0	11	8	5	5	37
Galveston, Tex.	2	4	4	8	11	9	17	16	16	5	4	4	481
Grand Haven, Mich.	1	0	4	8	17	15	19	17	9	5	4	0	324
Green Bay, Wis.	0	0	3	5	15	16	21	20	15	5	1	0	338
Hannibal, Mo.	1	2	7	9	15	18	15	15	11	5	3	1	526
Harrisburg, Pa.	1	1	3	8	12	19	27	18	8	4	0	1	355
Hatteras, N. C.	2	2	6	10	13	17	18	16	10	3	3	1	353
Havre, Mont.	0	0	0	2	7	34	25	24	8	0	0	0	236
Honolulu, T. H.	22	17	3	3	3	3	0	0	8	11	8	22	36
Huron, S. Dak.	0	0	1	4	13	24	24	21	11	2	0	0	343
Indianapolis, Ind.	1	1	7	9	13	19	18	14	11	3	3	1	467
Jacksonville, Fla.	1	2	4	5	11	16	25	20	11	3	0	1	795
Kansas City, Kans.	1	2	6	9	14	18	18	12	12	5	3	1	575
Keokuk, Iowa.	1	2	6	8	16	17	17	15	11	6	3	1	516
Key West, Fla.	1	2	2	4	8	17	19	22	17	5	1	2	539
Knoxville, Tenn.	0	3	6	8	13	18	21	18	9	1	2	1	581
La Crosse, Wis.	0	0	2	6	18	17	18	20	15	4	2	0	424
Lander, Wyo.	0	0	0	3	13	26	26	23	11	0	0	0	251
Lexington, Ky.	1	2	5	9	12	18	22	16	10	1	2	0	587
Little Rock, Ark.	2	5	7	12	10	16	16	14	10	3	3	1	601
Los Angeles, Cal.	14	14	20	14	2	2	2	10	10	8	2	0	44
Louisville, Ky.	2	3	7	10	12	18	20	12	10	3	3	0	532
Lynchburg, Va.	0	1	3	8	12	26	24	18	7	1	0	0	343
Marquette, Mich.	0	0	4	3	14	24	25	18	10	3	1	0	242
Memphis, Tenn.	3	4	7	11	12	18	18	13	8	3	3	2	509
Milwaukee, Wis.	1	0	5	9	15	17	16	19	12	4	2	0	374
Minneapolis, Minn.	0	0	1	4	15	21	18	22	14	4	1	0	366
Mobile, Ala.	2	4	5	6	9	16	22	18	13	2	1	1	757
Montgomery, Ala.	3	4	6	7	12	18	18	16	10	2	2	1	624

TABLE 1.—*Percentage of thunderstorm frequency for the 10-year period 1904–1913*—Continued.

Stations.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Storms in 10 years.
Nantucket, Mass	2	3	5	9	13	15	**21**	14	9	5	5	0	223
Narragansett Pier, R. I.	2	3	5	8	12	16	**23**	19	9	2	2	0	169
Nashville, Tenn.	1	3	7	11	12	18	**19**	15	9	2	3	1	566
New Haven, Conn.	1	2	5	5	14	19	**25**	18	10	3	1	0	261
New Orleans, La.	3	4	5	7	10	15	**20**	18	14	2	1	3	744
New York, N. Y.	1	1	3	9	14	18	**25**	19	9	3	0	0	284
Norfolk, Va.	0	2	4	8	15	21	**22**	19	7	2	1	0	406
Northfield, Vt.	0	0	2	3	14	18	**31**	21	10	3	0	0	242
North Platte, Nebr.	0	0	2	5	16	23	**25**	20	8	2	0	0	449
Oklahoma, Okla.	0	3	5	12	17	**19**	14	13	10	5	2	0	448
Omaha, Nebr.	0	1	3	8	16	**20**	18	17	12	6	2	0	499
Oswego, N. Y.	1	2	4	4	14	19	**22**	18	11	6	1	0	296
Palestine, Tex.	2	4	7	14	14	14	**15**	11	10	5	2	3	523
Pensacola, Fla.	2	4	5	6	9	14	**20**	19	14	3	1	2	814
Philadelphia, Pa.	0	3	5	7	15	18	**23**	19	7	4	1	0	319
Phoenix, Ariz.	0	2	3	3	4	4	29	**36**	11	3	3	1	332
Pierre, S. Dak.	0	0	1	4	14	23	**26**	22	8	3	0	0	359
Pittsburgh, Pa.	2	1	6	8	13	20	**22**	16	11	3	0	0	431
Port Crescent, Wash.	0	0	0	0	8	21	**25**	21	4	0	4	17	24
Port Huron, Mich.	1	2	3	8	14	18	**19**	**19**	9	5	2	0	325
Portland, Me.	1	0	4	3	12	19	**22**	18	11	4	0	0	153
Portland, Oreg.	2	6	4	7	**24**	9	17	15	7	6	4	0	54
Pueblo, Colo.	0	0	1	5	14	20	**29**	22	9	1	0	0	484
Raleigh, N. C.	1	1	4	6	13	19	**25**	19	9	2	1	0	469
Rapid City, S. Dak.	0	0	1	3	13	26	**28**	22	6	2	0	0	359
Red Bluff, Cal.	8	4	10	8	**25**	17	8	2	8	10	0	2	52
Richmond, Va.	0	0	4	9	13	20	**23**	21	8	2	1	0	415
Roseburg, Oreg.	0	0	9	6	14	17	**20**	11	17	3	0	3	35
Sacramento, Cal.	6	9	**26**	0	6	9	0	6	**21**	12	0	3	34
St. Louis, Mo.	1	2	7	10	13	**17**	16	**17**	11	4	3	0	526
St. Paul, Minn.	0	0	1	4	15	**22**	19	21	14	3	0	0	328
Salt Lake City, Utah.	3	1	5	7	8	16	20	**25**	12	4	0	0	356
San Antonio, Tex.	0	2	6	13	**16**	10	13	13	**15**	5	3	3	386
San Diego, Cal.	6	3	11	3	6	6	11	**17**	9	14	6	9	35
San Juan, P. R.	0	0	1	3	9	13	14	16	**20**	16	6	2	472
Sandusky, Ohio.	2	1	4	6	15	18	**21**	17	10	4	1	0	400
San Francisco, Cal.	12	**50**	12	0	0	0	0	0	0	13	0	13	8
Santa Fe, N. Mex.	0	1	3	4	9	15	**22**	24	12	3	0	0	732
Sault Ste. Marie, Mich.	0	0	4	4	9	17	**19**	**19**	15	11	3	0	209
Savannah, Ga.	1	3	3	6	11	17	**25**	20	11	2	0	1	606
Seattle, Wash.	0	3	10	3	10	**25**	15	14	12	3	2	2	59
Sioux City, Iowa.	0	0	1	6	15	**21**	**21**	21	11	4	2	0	436
Spokane, Wash.	0	0	0	8	14	**25**	24	18	10	3	0	0	108
Springfield, Ill.	2	1	8	11	16	**17**	**17**	13	9	4	3	0	509
Springfield, Mo.	2	2	5	10	14	**19**	18	12	10	4	3	1	572
Tampa, Fla.	1	2	3	3	10	17	**24**	22	14	3	0	1	944
Tatoosh Island, Wash.	8	6	2	2	2	4	9	6	**19**	12	14	14	53
Toledo, Ohio.	2	1	3	8	13	18	**23**	16	9	4	2	0	403
Topeka, Kans.	1	1	5	7	15	17	**18**	15	12	6	4	0	512
Vicksburg, Miss.	3	5	6	11	11	16	17	15	10	2	2	2	668
Walla Walla, Wash.	0	0	1	4	16	**28**	21	20	11	1	0	0	88
Washington, D. C.	1	2	4	8	12	18	**25**	17	9	2	1	0	392
Wichita, Kans.	0	2	4	9	17	**18**	**18**	14	12	5	2	0	531
Williston, N. Dak.	0	0	0	2	11	**29**	23	25	9	1	0	0	211
Wilmington, N. C.	1	3	5	6	11	18	**23**	21	9	3	1	0	511
Winnemucca, Nev.	0	0	4	4	12	**23**	**23**	21	11	3	1	0	142

STORMS AND HURRICANES IN JAMAICA, 1655–1915.

By MAXWELL HALL.

[Dated: Montego Bay P. O., Jamaica, W. I., Dec. 12, 1915.]

The Government Meteorologist for Jamaica, publishes in his Weather Report No. 449, for November, 1915, a *corrected* list of severe storms and hurricanes that have passed over Jamaica and done more or less damage there between the years 1655 and 1915. In correcting his list he has omitted those which, though represented on some charts as crossing Jamaica, were not felt as severe storms on the island or really missed it completely. The lower limit of wind velocity adopted for qualifying in this list is one of 60 miles an hour, and the storm of June 13, 1904, barely secured a place in the table on this basis; it had unusual interest because of two cyclones visiting the west end of the island. The corrected table is printed below.—C. A., jr.

Table of storms and hurricanes in Jamaica, 1655 to 1915.

Year.	Month.	Description.	Authority; notes.
1670	Oct. 7	Storm; the fleet at Jamaica driven ashore	[Poey: K. Johnstone Phys. Atl., 1856.
1689		Storm mentioned in early vols. Jamaica Almanac.	Gardner calls it a hurricane, ed. 1909, p. 73.
1712	Aug. 28	First hurricane experienced by English in Jamaica.	[Poey: Gardner, p. 112.
1714	Aug. 29	Some men-of-war driven ashore in a storm.	[Poey: K. Johnstone Phys. Atl.
1722	**Aug. 28**	Great hurricane damaged the whole island; center passed over Port Royal.	Atkins "Voyage to Guinea, Brazil, and the W. I.," 1737, p. 238; Long, v. 2, p. 145.
1726	Oct. 22	Hurricane swept east end of island	Long, v. 2, p. 146; Gardner, p. 115.
1744	**Oct. 20**	Great hurricane damaged whole island; 104 ships wrecked in harbor.	Clowes, 3, p. 275; Long, v. 2, p. 146; Gardner, p. 125.
1751	Sept. 2	Storm	Jamaica Almanac.
1780	**Oct. 3**	Great hurricane destroyed Savannah-la-Mar and damaged whole island.	Wm. Beckford "Descriptive account of the island of Jamaica," 1790. Bryan Edwards, ed. 1819, v. 1, p. 236. Reid, "Law of storms," etc.
1781	Aug. 1	Hurricane; 120 vessels wrecked in Kingston Harbor and at Port Royal.	Bryan Edwards, v. 1, p. 234, brief mention.
1784	July 30	Hurricane; wrecked all but 4 of vessels at Kingston and Port Royal.	Do.
1785	Aug. 27	Storm	Do.
1786	Oct. 20	Storm followed by great scarcity of food	Do.
1812	**Oct. 12–14**	Great hurricane damaged the whole island.	Jamaica mag.; Jam. phys. jour., 1835.
1813	Aug. 1	Storm damaged shipping and buildings in Kingston.	Jam. Courant, Aug. 2–9, 181, 1813; Bryan Edwards, v. 5, p. 77.
1813	Aug. 28	Storm at Savannah-la-Mar wrecked vessels.	
1815	Oct. 18, 19	Hurricane over eastern part of island, and great floods.	Jam. phys. jour., 1835; Bryan Edwards, v. 5, p. 78.
		Great destruction of houses in St. George, St. David, etc.	Jam. wthr. rpt., No. 352, Apr., 1908.
1818	Nov. 18, 20	Hurricane swept western part of island	
1832	Aug. 7	Violent storm that lasted but 3½ hours	Keith Johnstone, Phys. Atlas.
1837	Sept. 26, 27	Storm, probably felt all over the island	Jamaica Despatch; Reid: "Law of storms."
1844	Oct. 5	Storm over the western end of the island, Falmouth, Montego Bay, and Black River.	
1874	Oct. 31	Hurricane over the eastern half of the island.	
	Nov. 2	Center passed over St. Anns Bay	
1880	**Aug. 18**	Great hurricane; two cyclones damaged the eastern half of the island.	Jam. wthr. rep., v. 1, Introduction.
1886	June 27	Storm, whose center passed rapidly from the east end to Montego Bay.	Jam. wthr. rep., No. 67.
1886	Aug. 19, 20	Hurricane, whose center took nearly the same course.	Jam. wthr. rep., No. 69.
1903	**Aug. 11**	Great hurricane, whose center took nearly the same course.	U. S. Mo. wthr. rev., Sept., 1905; Jam. wthr. rep., v. 4, Introduction.
1904	June 13	Storm and heavy rains over west end of island, Montego Bay bridge destroyed.	U. S. Mo. wthr. rev., Aug., 1904; Jam. wthr. rep., v. 4, Introduction.
1912	**Nov. 18**	Great hurricane; two cyclones devastated the west end of the island.	Jam. wthr. rep., No. 411.
1915	Aug. 12, 13	Hurricane destroyed banana fields throughout the island, and damaged all the towns on the northern coast.	Jam. wthr. rep., No. 445.
1915	Sept. 25, 26	Storm	Jam. wthr. rep., No. 447.

Dates of great hurricanes are in **bold-face type.**

THE APPLICATION OF PHYSICAL PRINCIPLES TO PROBLEMS SUGGESTED BY OCEANIC CIRCULATION AND TEMPERATURES.[1]

By GEORGE F. MCEWEN.

[Dated: La Jolla, Cal.]

Most of our quantitative knowledge of the great ocean currents depends upon the difference between the true position of a ship and that determined from "dead-reckoning"; and upon observations of floating objects. This work has been supplemented by current meter observations in a few limited regions. Also the distri-

[1] Abstract of a paper presented at the San Francisco joint meeting of the Physical Society and Section B of the A. A. A. S., Aug. 2–7, 1915.
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bution of ocean temperatures, which is intimately connected with the motion of the water, is an important though indirect source of information concerning ocean currents. However, the temperature data have been used only in a qualitative way for this purpose. This paper is a summary of some of the quantitative results I have obtained by attempting to calculate the velocities of both horizontal and vertical currents from the distribution of temperatures.

First, assume that the average flow of the water in any direction is negligible, and the depth exceeds 100 meters. Assume the rate of absorption of radiant heat by the water to be an exponential function of the depth, and the rate of loss to be proportional to this exponential function and to a linear function of the temperature. From the observed relation of the mean annual surface temperature and the annual range of the surface temperature to the latitude and also from the assumption that the amount of radiant energy penetrating the water surface is proportional to the solar radiation incident on a horizontal surface at that time and latitude, the normal temperature can be expressed as a function of the depth, latitude, and time. The constants for this expression have been determined and the temperatures, computed for various positions, depths, and times at which normal values would be expected, agreed well with the observed values.

The influence of a horizontal current was estimated by adding to the differential equation first used a term expressing the rate of gain of heat due to the difference in temperature between the water flowing into an element of volume and that flowing out. By assuming the velocity along stream-lines from various points along the west coast of North America to be proportional to the average wind velocity over them, the temperatures as modified by this surface drift were computed and found to agree well with the observed values. Moreover the relative velocity of the wind and current thus found were in good agreement with those determined in other localities by direct measurement.

The relatively low temperature of the inshore water along the Pacific coast is regarded by many to be the result of the local up-welling of cold bottom water. Assuming a vertical current with a velocity proportional to that of the wind parallel to the coast as required by Ekman's theory of oceanic circulation, serial temperatures corresponding to average monthly values off San Diego, were computed and found to agree well with observations. Also some results computed from salinity observations confirmed the above conclusions regarding the circulation.

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The author expects to continue the study of this problem and to publish the methods and results in detail, as soon as possible.

ALBERT ADAMS YOUNG, 1836–1916.

The Chief of Bureau is glad of the opportunity to publish the following notice from "Climatological Data for the Indiana Section, December, 1915," as a testimonial of the esteem in which Mr. Young was held by this bureau. Such men are the backbone of our corps of cooperative observers, and it is with sincere regret and a sense of loss that we announce Mr. Young's decease.—C. A., jr.

The Rev. Albert Adams Young, for the last eight years cooperative observer for the Weather Bureau at Winona Lake, Ind., died at his home in that place on Friday, January 7, 1916. He was born in Hanover, N. H., in 1836; graduated from Dartmouth College in 1856; and later entered the ministry, holding pastorates at several places in Wisconsin, Iowa, and Illinois. His grandfather, Ebenezer Adams, was professor of mathematics and physics in Dartmouth College; his father, Ira Young, was professor of astronomy and physics in the same institution; and his brother, Charles Augustus Young, the astronomer, professor of astronomy at Dartmouth, and later at Princeton University. He is survived by his wife, Mary Sewall Young, and his two daughters, Elizabeth A. Young, who is in charge of the department of geography, Winona College, and Anna S. Young, who is head of the department of astronomy and director of the observatory at Mount Holyoke College.

Mr. Young was a deep student in the field of science. His microscope stood always at his desk, and his field glass was often in use. He discovered the double crystallization of quartz, and in the quarries near New Lisbon, Wis., the famous reptile tracks that bear his name. He loved flowers and his garden was one of the beauty spots most attractive to visitors at Winona.

As a boy he helped keep the weather records at Dartmouth College observatory, and his interest in the weather and the various problems of meteorology never waned. He kept a weather record continuously since his college days, and not infrequently he with his records was called into court to testify as to weather conditions. His retirement from the ministry gave him more leisure and he thereafter spent much time in weather study, working out various graphs and averages in connection with some line of original research. In his death the Weather Bureau loses one of its best observers.—*J. H. Armington, Meteorologist and Section Director.*

SECTION III.—FORECASTS.

FORECASTS AND WARNINGS FOR DECEMBER, 1915.

By EDWARD H. BOWIE, District Forecaster.

[Dated: U. S. Weather Bureau, Washington, Jan. 21, 1916.]

December, 1915, was characterized by (1) a great diversity in the intensity of and the paths followed by the centers of low pressure during their passage across the United States, and (2) by a preponderance of areas of high pressure from the Pacific coast rather than from Canada. The cause of the wide variations in the paths of centers of low pressure may be attributed to the pronounced fluctuations in the Aleutian subpermanent area of low pressure, of which nearly all storms that first appear in the Northwest at this season of the year are offshoots, or secondaries. The telegraphic reports from Alaska show that the Aleutian low-pressure area was well organized during two short periods, namely, 1st to 6th and 16th to 22d. At other times during December, 1915, this low area was not well defined and pressures at the several Alaskan stations averaged relatively high. With regard to the predominance of highs from the Pacific Ocean instead of Alaska, the inference is based on the cabled reports from Honolulu and the south coast of Alaska that the permanent high off the California coast was of large area and the pressures within were above normal and that the highs that enter the United States from the Pacific Ocean were but offshoots from it. Moreover, it was not until the last week in December that areas of high barometer entered the United States from Canada, and then when the reports from Honolulu showed that the high-pressure area off the California coast had presumably lost intensity and become ill defined. Another peculiarity of the month was the unusual number of secondary disturbances that accompanied Northwest lows. The first of these formed over Nevada on the 4th and passed thence to Texas on the 6th, whence it was prevented from following a usual northeast course by an area of high barometer of great magnitude that had its center over the Great Lakes from the 3d to the 6th. An Alberta storm made its appearance on the 5th and traveled eastward along the northern border during the 6th, 7th, 8th, and 9th, and on the 8th it developed a secondary center of low pressure off the New Jersey coast. Again, the Alberta low (IV on Chart III) which first made its appearance over British Columbia on the 8th, reached the Ohio Valley on the 11th, and on that date a secondary storm center developed off the Carolina coast, and moving northward became a disturbance of great intensity in New England on the 13th. Similarly, low V which made its appearance in Alberta on the 13th, developed a secondary over eastern Tennessee on the 17th, which moved rapidly northeastward and gained great intensity on the 18th when passing over New England. Moreover, low VII, a northern Rocky Mountain storm, which first made its appearance on the 23d, on reaching the lower Lake region, developed a secondary center over Virginia on the 25th, and this gained intensity and moved northeast along the coast, attended by rains, sleet, snow, and shifting gales. It will be noted that all these secondary centers attended Northwest lows. As a matter of fact, these lows—the Alberta, north Pacific, and northern Rocky Mountain—are most prolific of secondary storm formations and must be carefully watched by the forecaster, as stated in MONTHLY WEATHER REVIEW, Supplement No. 1, July, 1914.

As might be expected, the majority of the high areas being of Pacific origin, few of these were attended by unusually low temperatures. In fact, the only extremely low temperatures during the month occurred during its last decade and these in connection with highs that entered the United States from Canada.

Great Lakes.—On the Great Lakes the season for the display of storm warnings ended on December 20, and press and other reports are to the effect that the 1915 season of navigation was one of small marine loss of life and property. The necessity for giving all possible information to shipping on the Great Lakes during the remaining days of the season of navigation, when winds and weather are most dangerous to navigation, was recognized and advance information was sent when conditions demanded. Thus on Thursday, the 2d, the following advisory information was sent Lake stations:

> Winds of moderate force, mostly west to south, and generally fair weather with normal temperatures probable on Great Lakes during the remainder of this week. Disturbance now approaching the north Pacific coast will reach the Great Lakes Sunday or Monday and be attended by high winds and rain and snow. Distribute this information to shipping.

The storm referred to reached the Lakes at the beginning of the following week, and on the 7th storm warnings were ordered for the Great Lakes, except extreme southern Michigan, and strong winds and snows and rains occurred as forecast. On Thursday, the 9th, the following advisory information was sent stations on the Great Lakes:

> Storm forming over eastern Colorado and it will in all probability move toward the Great Lakes and cause snow and strong winds by Friday night and on Saturday. Advise shipping to exercise caution.

Storm warnings were displayed on the 10th on Lake Michigan. The storm in question moved due east instead of northeast and dissipated on the afternoon of the 11th on reaching the middle Mississippi Valley. Storm warnings were again ordered for Lake Michigan on the 15th and for Lakes Superior, Huron, and Erie on the 16th, in advance of a storm that moved from Texas northeastward over the middle Mississippi Valley and thence to lower Michigan. Strong winds with snow and rain occurred on all lakes where warnings were displayed. The highest velocity reported was 52 miles per hour from the southeast during the night of the 16th, at Erie, Pa.

Atlantic coast.—On the 8th storm warnings were ordered on the coast from Delaware Breakwater to Eastport, in connection with a storm that was moving eastward from the Great Lakes, and on the 9th storm winds occurred as follows:

> Delaware Breakwater, 44 miles per hour from northwest; New York, 48 miles per hour from northwest; Sandy Hook, 52 miles per hour from northwest; Block Island, 48 miles per hour from northwest.

On the 11th storm warnings were ordered from Savannah to Boston, as there were evidences of a disturbance forming off the South Atlantic coast. Strong winds

occurred along the coast south of the mouth of the Delaware on the 12th, when the disturbance was off Cape Hatteras. On the morning of the 13th this storm gave evidence of changing its course to northerly and northeast storm warnings were ordered displayed from Sandy Hook to Eastport. Special observations at noon on this day gave conclusive indications that the storm would greatly increase in intensity, and the following advisory warning was sent New England and Middle Atlantic coast stations:

Storm off New Jersey coast, increasing in intensity and moving northeast. Strong shifting gales indicated for the Atlantic coast from Sandy Hook north to Eastport this afternoon and to-night. Advise all shipping.

This storm became one of the severest storms of the year on the Middle Atlantic and New England coasts, and it was attended by heavy sleet and snows in New England and New York. Winds of force 9 to 11 occurred along the New England and New Jersey coasts, and the pressure fell to below 29 inches on the New England coast. The warnings, however, were timely and no considerable amount of shipping was lost. A number of barges and small boats were driven ashore in the harbors of New York and New England. Storm warnings were again displayed on the 17th from Boston to Jacksonville and on the morning of the 18th the display was extended to Eastport. Storm winds occurred on the 18th over the entire area covered by the warnings. The highest winds reported on this date were as follows:

Jacksonville, 48 miles per hour from southeast; Charleston, 48 miles per hour from south; Hatteras, 52 miles per hour from southwest; Norfolk, 52 miles per hour from southwest; Delaware Breakwater, 72 miles per hour from northwest; New York, 64 miles per hour from northwest; and Block Island, 48 miles per hour from northwest.

On the 23d warnings were ordered displayed from Delaware Breakwater to Eastport, as a storm of considerable intensity was then moving eastward from the Great Lakes, but this storm lost intensity on reaching the St. Lawrence Valley and the winds sufficient to justify warnings did not materialize.

On the 24th, however, another storm moved rapidly eastward from the Rocky Mountain region until at 8 p. m. of that date its center was over the middle Mississippi Valley. Warnings were ordered, therefore, on the Atlantic coast from Jacksonville, Fla., to Boston, Mass., and on the morning of the 25th the display was extended northward to Eastport. During the 25th this storm moved rapidly eastward, and the evening of that date its center was over the Middle Atlantic States, whence it moved rapidly northeastward. On the morning of the 26th the lowest pressure was 28.90 inches, at Hartford, Conn. Storm winds occurred over the entire areas covered by warnings, the highest velocities being:

Jacksonville, 72 miles per hour from southwest; Norfolk, 60 miles per hour from west; Delaware Breakwater, 68 miles per hour from west; New York, 88 miles per hour from northwest; Block Island, 84 miles per hour from west; Nantucket, 72 miles per hour from southwest; Boston, 48 miles per hour from northwest; Portland, 52 miles per hour from west; and Eastport, 48 miles per hour from southeast.

Reports indicate that shipping was fully warned and little loss resulted from the severe storm winds.

On the morning of the 28th a storm was charted over Louisiana and at 8 p. m. of that date its center was over Mississippi and moving northeast. Storm warnings were then displayed on the Atlantic coast from Jacksonville, Fla., to Portland, Me., and the morning of the 29th the display was extended to Eastport. This storm advanced rapidly northeastward; it caused heavy snows and sleet in the Ohio Valley and the southern portion of the region of the Great Lakes, the interior of New York, and New England, and winds of gale force along the Atlantic coast from Savannah to Eastport. The highest velocities reported were:

Pensacola, 72 miles per hour from southwest; Savannah, 34 miles per hour from south; Charleston, 36 miles per hour from south; Hatteras, 42 miles per hour from southwest; Norfolk, 52 miles per hour from southwest; Sandy Hook, 60 miles per hour from northeast; Block Island, 60 miles per hour from northeast; Nantucket, 52 miles per hour from northeast; and Boston, 38 miles per hour from northeast.

East gulf coast.—Storm warnings were ordered on the morning of the 17th from Bay St. Louis, Miss., to Cedar Keys, Fla., the information being to the effect that strong shifting winds would become northwest the following night. At the time the warning was issued a storm of considerable intensity was over the lower Mississippi Valley. The highest velocity reported in the region where storm warnings were displayed was 48 miles per hour from the southwest at Pensacola the afternoon of the 17th. On the 20th the following advisory warning was sent east gulf and south Atlantic ports:

There are some indications of a disturbance over the east Gulf of Mexico.

This disturbance crossed extreme southern Florida during the evening of the 20th and it caused a northwest gale of 52 miles an hour at Key West and of 30 miles an hour at Tampa. The official in charge at Pensacola, under date of January 3, 1916, forwards the following extract from the log of the fishing schooner *Ida S. Brooks*, Capt. Frank Cooney, jr., concerning the storm:

Left Pensacola on December 18, 1915, bound for Campeche Banks, wind north, light all day Sunday, 19th; wind northeast blowing. Took in mainsail at 3 o'clock. At 8 o'clock took in both jibs, blowing gale from northeast.

Monday 20th: 6 a. m., running under foresail; strong breeze. At 8 a. m. the wind went around to southwest and died out. Calm for about 20 minutes, then hit from about west-southwest. Took in foresail which vessel could not carry. We were then in about latitude 25° 50′ N., longitude 87° 00′ W. At 9 a. m. the barometer read 29.25″ and the vessel went on her beam ends. It was blowing so hard that nobody could stand on deck. Vessel going lower all the time. Went so low that she lost her bearings and could not come back. She was so full of water that she began filling through after companionway. Stern all under water. Cut lanyards from outside on main rigging and the wind took both spars and bowsprit. After getting clear of spars and rigging put out drag so as to hold vessel up to wind. The wind hauled to northwest and blew hard all day. The vessel drifting about south with ensign union down.

Tuesday, 21st: Kept good lookout. The wind went north-northwest. Weather fine. We had only our jumbo boom on which we have our ensign. At noon, latitude 25° 42′, Pensacola bears by D. R. [dead reckoning] north, distance 278 miles.

Thursday, 23d: Spoke S. S. *De Larrinaga* 11:30 p. m.; Capt. H. C. Kramer reported us by wireless. The captain offered tow to Galveston; thanked him and told him I thought I could get vessel to port. Latitude 25° 54′, longitude 86° 09′.

Saturday, 25th: 6 a. m., rain squall struck us. 8 a. m., wind west; heading north by west making about 2 miles per hour under jury rig. 9 a. m., whirlwind and water spouts all around us, wind struck from northwest, vessel heading northeast by east.

Friday, December 31: Arrived at sea buoy Pensacola 8 a. m., wind east, strong breeze.

(Signed) FRANK COONEY, Jr.,
Captain Schooner "Ida S. Brooks."

Storm warnings were again displayed on the 24th on the coast from Bay St. Louis, Miss., to Tampa, when a storm of considerable intensity was over the middle Mississippi Valley. This storm passed without causing winds of more than 30 miles an hour in this region. On the morning of the 28th northwest storm warnings were displayed from Bay St. Louis to Apalachicola, the storm at this time being over Louisiana. This disturbance advanced eastward, increased greatly in intensity, and caused gales on the coast where warnings were displayed. The highest velocity reached was 72 miles an hour from southwest during the night of the 28th at Pensacola.

COLD WAVE AND FROST WARNINGS.

Warnings of frosts were issued on a number of dates for the south Atlantic and Gulf States and the Florida Peninsula. The most important of these were in connection with frosts in Florida on the 14th, 15th, 21st, 23d, and 26th.

Cold-wave warnings were issued on the 16th for western Tennessee, Alabama, Mississippi, and northwest Florida; on the 24th for Tennessee, Mississippi, Alabama, Georgia, and extreme northwest Florida; and on the 27th for western Tennessee and Mississippi. Decided falls in temperature occurred in all instances, but no abnormally low temperatures were recorded.

Heavy-snow warnings were issued on the 24th for northern Indiana, northern Ohio, and extreme southern Michigan, and on the 26th heavy-snow warnings for the interior of northern New England were ordered. These warnings were verified in all instances.

DISTRICT WARNINGS DURING DECEMBER.

Chicago forecast district.—No warnings of any kind were required until the 24th, when warnings of moderately heavy snow were issued for northern Illinois and the vicinity of St. Louis, Mo. The warnings were verified. On the evening of the 27th warnings of heavy snow were issued for southeastern Missouri and southern Illinois and again for southeastern Illinois on the evening of the 28th. These warnings were not verified. There was heavy precipitation in southeastern Illinois during the night of the 28th–29th in the form of rain and sleet, although the temperature was freezing or below.

On the evening of the 25th a disturbance of considerable force was centered over North Dakota, whence it moved directly eastward across the Lake region and was followed by a decided increase in pressure throughout the Northwest. Cold-wave warnings were issued for the entire Northwest, except western Montana, and the Plains States either the evening of the 25th or the morning of the 26th. These warnings were fully verified in northwestern Wisconsin, Minnesota, and North Dakota, and partly verified in the other States. Warnings were again issued for North Dakota, eastern Montana, and northern Wyoming on the morning of the 28th, and for the remainder of the Northwest including western Nebraska and Minnesota, on the evening of the 28th and the morning of the 29th. These warnings were only partially verified, the cold wave not advancing east of the 100th Meridian on account of the fact that the low pressure area which was over the southeastern slope (29.40″ at| Amarillo, Tex.) on the morning of the 29th, failed to advance, filling up instead.—*Charles L. Mitchell, Assistant Forecaster.*

Portland, Oreg., Forecast District.—During December important storm warnings were issued on six separate occasions, viz, on the 4th, 5th, 7th, 19th, 20th, and 27th. Several other warnings were issued which were fully verified.—*T. F. Drake, Assistant Forecaster.*

San Francisco Forecast District.—A moderate storm moved in from the ocean on the 2d, and gave precipitation over the entire district with strong southerly winds on the north coast. Another storm covering the period 11th–14th, gave precipitation over the northern portion of the district with strong southerly winds on the central coast. The reports received from incoming vessels indicated much higher winds at sea than the coast stations showed.

An area of high pressure moved southward over British Columbia at the close of the month and gave damaging frosts in northern California and rain and snow in southern California. The conditions were forecast successfully in all cases.—*G. H. Willson, District Forecaster.*

Denver Forecast District.—The cold-wave warnings issued for western Utah on the 15th were not fully verified, although an anticyclonic area occupied the Great Basin on the following morning and a temperature of 12° F. was reached at Modena. On the morning of the 26th an extensive, cold, high-pressure area was spreading rapidly eastward across Montana and Wyoming and southward over the Plateau region. Cold-wave warnings were issued for central and southwestern Colorado and central Arizona. These warnings were fully verified in central Colorado and a sharp fall in temperature occurred in central Arizona. On the evening of the 26th the temperature at Roswell, N. Mex., was 60°, and a cold-wave warning was issued for southeastern New Mexico. The warning was followed by a 24-hour fall in temperature of 40 degrees over the southeastern portion of the State. On the morning of the 29th a cold anticyclonic area was advancing southward over Montana, and cold-wave warnings were issued for eastern Colorado. This warning was fully justified in northeastern Colorado where zero temperatures occurred; the cold wave did not reach southeastern Colorado, however, as the southwestern storm on that date caused a continuance of southerly winds in that part of the State. The cold-wave warning issued for north-central Arizona on the 30th was a failure, as the storm remained stationary in northern Arizona, prolonging the cloudy weather.—*Frederick W. Brist Assistant Forecaster.*

New Orleans Forecast District.—Cold-wave warnings were issued on the 15th, 16th, 24th, and 27th.

The cold wave on the 17th gave a fall in temperature of 20 to 30 degrees over Oklahoma, Arkansas, eastern Texas, and northern Louisiana, but the verifying temperature was recorded at only a few stations.

The cold wave on the 25th gave a fall in temperature of 20 to 30 degrees over Arkansas, Louisiana, and the northern portion of eastern Texas, freezing temperature over the interior of eastern Texas, and about 40° F. on the Gulf coast.

The cold wave on the 28th gave a fall in temperature of 20 to 30 degrees over Arkansas, eastern Texas, and northern Louisiana, with temperatures of 20° to 32° in Arkansas, 24° to 32° over the interior of eastern Texas, and 38° to 42° on the Texas coast.

Storm warnings were issued for the Louisiana and Texas coasts on the 24th and for the Texas coast on the 27th, and verifying winds occurred at some stations.—*I. M. Cline, District Forecaster.*

SECTION IV—RIVERS AND FLOODS.

RIVERS AND FLOODS OF DECEMBER, 1915.

By ALFRED J. HENRY, Professor in Charge of River and Flood Division.

[Dated: Washington, January 31, 1916.]

Flood-producing rains occurred on two occasions during the month; the first was in connection with general rains that were associated with low No. v, Chart III. The rains were heavy, over 1 inch in 24 hours in Arkansas and northeastern Texas on the 16th; the Ohio Valley, Tennessee, Kentucky, Alabama, and northern Georgia on the 17th, and the Atlantic drainage, including Georgia, on the 18th. The second period of flood-producing rains began on the 27th, in connection with low No. VIII–A, Chart No. III. This low was associated with heavy rains on the 28th in Alabama, Mississippi, eastern Tennessee, and northern and central Georgia. The heavy rains in Tennessee, Alabama, and Georgia continued during part of the 29th and extended into western North Carolina on the same date.

The rains of the first of the above-named periods caused only a slight flood wave in the upper reaches of the Ohio on the 19th. The southern tributaries, however, while not in severe flood, carried much more water than the northern and, as a result, flood stages were reached at Evansville, Ind., on the 20th, several days before the influence of the minor flood wave from the upper river could be felt.

Evidently the lower river was maintained in flood as a result of the water contributed by the Cumberland and Tennessee Rivers during the closing days of the month. Tables 1 and 2 show points along the Ohio and its tributaries at which the rivers reached and passed the flood stage during December.

The second period of heavy rains caused flood stages in the rivers of the East Gulf and South Atlantic States, as shown in detail in Table 3. The previous rains caused high water in general but flood stages at only a very few points. The month closed with high water in practically all of the streams in the South Atlantic and East Gulf States.

Table 4 shows the flood stages reached in the rivers in other parts of the country. As may be seen, these were of little importance and there was an absence of severe floods outside of the lower Ohio Valley, the East Gulf, and the South Atlantic States.

TABLE 1.—*Floods in the Ohio River, December, 1915.*

River.	Station.	Flood stage.	Above flood stage.		Crest.	
			From—	To—	Stage.	Date.
		Feet.			*Feet.*	
Ohio	Pittsburgh, Pa.	22	19	19	22.6	19
Do.	Beaver Dam, Pa.	30	19	19	31.7	19
Do.	Point Pleasant, W. Va.	40			39.9	21
Do	Cloverport, Ky.	40	21	26	42.2	24
Do.	Evansville, Ind.	35	20	31	41.1	26
Do.	Henderson, Ky.	33	21	31	38.9	25 & 26
Do.	Mount Vernon, Ind.	35	21	31	39.8	26
Do.	Shawneetown, Ill.	35	22	31	40.3	27 & 28

TABLE 2.—*Floods in tributaries of the Ohio, December, 1915.*

River.	Station.	Flood stage.	Above flood stage.		Crest.	
			From—	To—	Stage.	Date.
		Feet.			*Feet.*	
Kiskiminetas	Saltsburg, Pa.	8	18	18	10	18
Monongahela	Lock No. 4, Pa.	31	18	19	33.7	18
Do.	Greensboro, Pa.	20	18	19	24.1	18
Do.	Fairmont, W. Va.	25	18	18	25	18
Little Kanawha	Glenville, W. Va.	22	18	18	22	18
Do.	Creston, W. Va.	20	19	19	20.7	19
Tuscarawas	Norris Point, Ohio.	8	30	31	10.2	31
Scioto	Circleville, Ohio.	6	18	19	6.9	18
Do.	do.	6	29	31	9.7	31
Licking	Farmers, Ky.	22	18	19	24.8	19
Do.	Falmouth, Ky.	25	17	19	31	18
Kentucky	Beattyville, Ky.	30	17	19	36.5	19
Do.	High Bridge, Ky.	30	18	21	34.6	19
Do.	Frankfort, Ky.	31	17	22	37.2	19
Cumberland	Burnside, Ky.	50	18	19	54.5	19
Do.	Carthage, Tenn.	40	20	20	40.2	20
Do.	Nashville, Tenn.	40			39.9	24
Tennessee	Knoxville, Tenn.	12	19	20	17.7	19
Do.	Chattanooga, Tenn.	33	20	21	34.4	21
Do.	Riverton, Ala.	32	23	26	33.2	25 & 26
Do.	do.	32	31	31	32.2	31
Holston	Rogersville, Tenn.	14	19	19	15.2	19
North Fork of Holston	Mendota, Va.	8	18	20	11	18
French Broad	Asheville, N. C.	4	18	20	5.4	18
Do.	do.	4	29	31	6.2	29
French Broad	Dandridge, Tenn.	12	18	19	13	19
Do.	do.	12	30	30	12.6	30
Nolichucky	Birds Bridge, Tenn.	10	30	30	10.2	30
Big Pigeon	Newport, Tenn.	6	18	18	12	18
Do.	do.	6	29	29	10	29
Clinch	Clinton, Tenn.	25	19	20	29.7	19

TABLE 3.—*Floods in southern rivers, December, 1915.*

River.	Station.	Flood stage.	Above flood stage.		Crest.	
			From—	To—	Stage.	Date.
		Feet.			*Feet.*	
Alabama	Montgomery, Ala.	35	30	31	41.5	31
Tallapoosa	Milstead, Ala.	40	29	30	47.2	30
Tombigbee	Demopolis, Ala.	39	30	31	44.2	31
Black Warrior	Tuscaloosa, Ala.	46	29	31	51.6	31
Chattahoochee	Norcross, Ga.	16	19	19	17.8	19
			30	30	21.4	30
Do.	West Point, Ga.	20	29	30	22.2	30
Ocmulgee	Macon, Ga.	18	20	20	19.1	20
Do.	Abbeville, Ga.	11	26	28	11.9	27
Broad (in Georgia)	Carlton, Ga.	11	18	19	16.7	19
			29	30	16.0	29
Santee	Rimini, S. C.	12	21	26	13.1	23 & 24
Saluda	Chappells, S. C.	14	31	31	15.0	31
Wateree	Camden, S. C.	24	30	31	28.8	31
Catabwa	Catawba, S. C.	11	30	31	14.0	30
Broad (in South Carolina).	Blair, S. C.	14	31	31	14.6	31
Roanoke	Weldon, N. C.	30	21	21	30.9	21
Staunton	Randolph, Va.	21	31	31	21.2	31
Black	Black Rock, Ark.	14	17	22	15.9	19
			29	31	16.5	31
Nueces	Cotulla, Tex.	9.6	1	1	9.6	1

TABLE 4.—*Floods in other rivers, December, 1915.*

River.	Station.	Flood stage.	Above flood stage.		Crest.	
			From—	To—	Stage.	Date.
		Feet.			*Feet.*	
Hudson	Troy, N. Y.	14	28	29	14.7	28
Willamette	Eugene, Oreg.	10	6	7	13.5	6
Clackamas	Cazadero, Oreg.	8	22	22	14.2	22
Santiam	Jefferson, Oreg.	10	22	22	10.5	22

Hydrographs for typical points on several principal rivers are shown on Chart I. The stations selected for charting are Keokuk, St. Louis, Memphis, Vicksburg, and New Orleans, on the Mississippi; Cincinnati and Cairo, on the Ohio; Nashville, on the Cumberland; Johnsonville, on the Tennessee; Kansas City, on the Missouri; Little Rock, on the Arkansas; and Shreveport, on the Red.

SNOWFALL IN HIGH ALTITUDES, DECEMBER, 1915.

[Compiled from reports of section directors.]

Detailed reports on the amount of snowfall both in high altitudes and in the lowlands of Western States will be found in the publication entitled Climatological Data for December, 1915.

In general the snowfall of December in the Pacific Coast and Rocky Mountain States was up to normal; in some localities it slightly exceeded the normal. In the Plateau States of Nevada and Utah the distribution was somewhat irregular; in the last-named a line drawn from the northwest to the southeast corner of the State will separate roughly the regions of light snowfall from those of moderate to heavy snowfall, the latter being in the northeastern part of the State.

In Arizona a general storm at the close of the month left a considerable snow cover in the higher levels of the central and northern counties.

At this date (Jan. 29, 1916), telegraphic advices from Western States show that the snowfall in the mountains of California, Arizona, Nevada, and Utah, and the southwestern portion of Colorado, including northwestern New Mexico, during January, 1916, was exceptionally heavy.

MEAN LAKE LEVELS DURING DECEMBER, 1915.

By UNITED STATES LAKE SURVEY.

[Dated: Detroit, Mich., Jan. 4, 1916.]

The following data are reported in the Notice to Mariners of the above date:

Data.	Lakes.			
	Superior.	Michigan and Huron.	Erie.	Ontario.
Mean level during December, 1915:	*Feet.*	*Feet.*	*Feet.*	*Feet.*
Above mean sea level at New York	602.72	579.51	571.37	244.78
Above or below—				
Mean stage of November, 1915	−0.17	−0.01	−0.09	−0.16
Mean stage of December, 1914	+0.63	−0.08	−0.04	−0.05
Average stage for December, last 10 years	+0.47	−0.63	−0.36	−0.72
Highest recorded December stage	−0.41	−3.01	−2.16	−2.83
Lowest recorded December stage	+1.52	+0.51	+0.51	+1.35
Average relation of the December level to—				
November level	−0.2	−0.2	−0.1	−0.1
January level	+0.3	+0.2	0.0	−0.1

SECTION V.—SEISMOLOGY.

SEISMOLOGICAL REPORTS FOR DECEMBER, 1915.

By WILLIAM J. HUMPHREYS, Professor in charge of Seismological Investigations.

[Dated: U. S. Weather Bureau, Washington, D. C., Feb. 3, 1916.]

TABLE 1.—*Noninstrumental earthquake reports, December, 1915.*

Day.	Approximate time, Greenwich Civil.	Station.	Approximate latitude.	Approximate longitude.	Intensity (Rossi-Forel).	Number of shocks.	Duration.	Sounds.	Remarks.	Observer.
		ARKANSAS.								
	H. m.		° ′	° ′			*Secs.*			
7	18 40	Black Rock	31 08	91 04	2	1	30			S. J. Howe.
	18 40	Black Rock	31 08	91 04	2	1	30			N. F. Coffey, jr.
	18 40	Blytheville	35 55	89 53		1				J. K. Sartain.
	18 40	Brinkley	34 53	91 07	4	1				H. L. D. Whitson.
	18 40	Forest City	35 02	90 43	5	1				L. Tierley.
	18 40	Hardy	36 19	91 22	2	1	30			C. A. Caywood.
	18 40	Hunter	35 06	91 05	5	1	30	Rumbling	Shook articles off shelves	J. R. High.
	18 40	Jonesboro	35 51	90 38	5	1				Benedictine Sisters.
	18 40	Little Rock	34 45	92 06	3–4	1	5			G. H. Speaker.
	18 40	Marion	35 14	90 10	4	1	4			S. A. Johnson.
	18 40	Newport	35 36	91 13		1				A. J. Shell.
	18 40	Ravenden	36 15	91 12	4	1			Windows rattled	L. H. Walker.
	18 40	Wynne	35 14	90 44	2	1	5			J. M. Larkan.
		CALIFORNIA.								
1	14 05	Corona	33 52	117 35	3	1	½			J. W. Garthwaite.
	14 05	Holcomb Valley	34 17	117 05		1				J. M. Henry.
	14 05	Redlands	34 04	117 12	4	1	1	Rumbling		P. W. Moore.
	14 05	Riverside	33 58	117 21	3–4	1				(From press report.)
14	15 00	Seven Oaks	34 06	117 10	3	1	1			E. N. Munns.
27	7 24	Lonoak	36 20	122 00	3	1				M. L. Griffin.
	7 24	Salinas	36 36	122 40						Miss Ruth Abbott.
	7 24	San Jose	37 20	121 54						(From press report.)
	7 24	Santa Cruz	36 57	122 02	5	1	10	Rumbling	Windows rattled	W. R. Springer.
	7 24	Soledad	36 28	121 16						A. H. Abbott.
	7 24	Spreckels	36 35	121 38	5	2				Paul Holz.
	7 24	Watsonville	36 55	121 46	5	1	10	Rumbling		Spreckels Sugar Co.
31	12 20	Eureka	40 48	124 11	3			Faint		J. P. Spetz.
	12 20	Shively	40 25	123 56	3	1	2			Frank Essig.
		ILLINOIS.								
7	18 40	Anna	37 27	89 18	4	1	7			J. I. Hale.
	18 40	Cairo	37 00	89 10	5	2	14	Faint	Shook buildings	U. S. Weather Bureau.
	18 40	Golconda	37 24	88 31	4	1	5			C. A. Werner.
	18 40	Harrisburg	37 45	88 34	2-3	1	15		Dishes rattled	Clarence Bonnell.
		KENTUCKY.								
7	18 40	Benton	36 51	88 20	2	1				
	18 40	Calvert City	37 02	88 18	4	1	5		Doors moved	J. C. Nobel.
	18 40	Clinton	37 40	89 00	4	1	10			Otis Jackson.
	18 40	Fulton	36 30	88 52	4	1				(From press report.)
	18 40	Hickman	36 35	89 12	4					J. C. Sexton.
	18 40	Kevil	37 06	88 53	5	1	5			M. Kempendall.
	18 40	Lone Oak	37 03	88 42	3	2	4			Mrs. R. C. Gore.
	18 40	Mayfield	36 45	88 38	3	1	10			T. J. Cross.
	18 40	Murray	36 37	88 17	4	1			Dishes rattled	E. H. Robertson.
	18 40	Paducah	37 06	88 37	3–4	1				F. L. Brown.
	18 40	Wickliffe	36 58	89 06	5	1				W. L. Timeall.
		MISSISSIPPI.								
7	18 40	Tupelo	34 16	88 36	3	1	10			W. S. Vincent.
		MISSOURI.								
7	18 40	Cardwell	36 04	90 16	5	1	5	Rumbling		E. M. Perry.
	18 40	Caruthersville	36 14	89 40	5	1				H. E. Averill.
	18 40	New Madrid	36 35	89 32	3	1	1			Miss Josie Smith.
		NEVADA.								
18	9 00	Winnemucca	40 58	117 43	4	1	5			U. S. Weather Bureau.
		SOUTH CAROLINA.								
13	0 55	Charleston	32 47	79 56	3	1		Faint		Dr. J. S. Rhame.
	0 55	Charleston	32 47	79 56	3–4	1	1	Loud		W. T. Tarrant.
	0 55	Summerville	33 05	80 14	2	1	¼	Faint		Miss E. H. Gadsden.
		TENNESSEE.								
7	18 40	Brownsville	35 35	89 15	2	1	5			Robt. Y. Moses.
	18 40	Memphis	35 09	90 03	2	1	15		Dishes rattled	U. S. Weather Bureau.
	18 40	Milan	35 55	88 46	3–4	2	10	Rumbling	Shook buildings	O. F. Cantwell.
	18 40	Murfreesboro	35 52	86 27						E. F. Wright.
	18 40	Springville	36 17	88 11	3–4	1	2	Loud		H. A. Boden.
	18 40	Union City	36 27	89 05	5	2	5	Rumbling	Shook buildings	J. R. Oliver.
		WASHINGTON.								
10	20 45	Spokane	47 40	117 25	3–4	1			Shook buildings	U. S. Weather Bureau.

TABLE 2.—*Instrumental seismological reports, December, 1915.*

Time used: Mean Greenwich, midnight to midnight. Nomenclature: International.

[For significance of symbols see this REVIEW, June, 1915, p. 289.]

Date.	Character.	Phase.	Time.	Period. T.	Amplitude. A_E	Amplitude. A_N	Distance.	Remarks.
Alaska. *Sitka. Magnetic Observatory.* U. S. Coast and Geodetic Survey. J. W. Green.								
Lat., 57° 03′ 00″ N.; long., 135° 30′ 06″ W. Elevation, 15.2 meters.								
Instruments: Two Bosch-Omori, 10 and 12 kg.								
Instrumental constants: E V=10 T_0=17.4; N V=10 T_0=15.6								
1915. Dec. 12	.....	eL.....	*H. m. s.* 21 34 01	*Sec.* 12	.....	.....	.....	Nothing on E-W.
		M.....	21 36 48	10	.....	20	.....	
		C.....	21 41 00	.....	.....	.....	.....	
Arizona *Tucson. Magnetic Observatory.* U. S. Coast and Geodetic Survey. F. P. Ulrich.								
Lat., 32° 14′ 48″ N.; long., 110° 50′ 06″ W. Elevation, 769.6 meters.								
Instruments: Two Bosch-Omori, 10 and 12 kg.								
Instrumental constants: E V=10 T_0=16; N V=10 T_0=19.6								
1915. Dec. 13	.....	e.....	*H. m. s.* 5 13 29	*Sec.* 3	.....	.....	.....	Very faint. Recorded on magnetogram at 5h 15m.
		M.....	5 14 07	4	10	10	.....	
		F.....	5 16 22	3	.....	.....	.....	
31	.....	P_E.....	12 23 36	4	.....	.....	.....	
		L_E.....	12 29 06	11	.....	.....	.....	
		L_N.....	12 29 24	.....	.....	.....	.....	
		M.....	12 29 37	11	470	40	.....	
		C.....	12 31 00	10	.....	.....	.....	
		F_N.....	12 36 00	.....	.....	.....	.....	
		F_E.....	13 02 00	.....	.....	.....	.....	
California. *Berkeley. University of California.*								
Lat., 37° 52′ 16″ N.; long., 122° 15′ 37″ W. Elevation, 85.4 meters.								
(See Bulletin of the Seismographic Stations, University of California.)								
California. *Mount Hamilton. Lick Observatory.*								
Lat., 37° 20′ 24″ N.; long., 121° 38′ 34″ W. Elevation, 1,281.7 meters.								
(See Bulletin of the Seismographic Stations, University of California.)								
California. *Point Loma. Raja Yoga Academy.* F. J. Dick.								
Lat., 32° 43′ 03″ N.; long., 117° 15′ 10″ W. Elevation, 91.4 meters.								
Instrument: Two-component, C. D. West seismoscope.								
1915. Dec. 8	.....	.....	*H. m. s.*	*Sec.*	μ *350	μ *350	.....	These tremors occurred at unknown hours being recorded during the 24 hours preceding 15h on dates given. No shocks felt.
		.....	.....	.....	*300	*300	.....	
*Amplitude on instrument.								
California. *Santa Clara. University of Santa Clara.* J. S. Ricard, S. J.								
Lat., 37° 20′ 36″ N.; long., 121° 57′ 03″ W. Elevation, 27.43 meters.								
(See record of the Seismographic Station, University of Santa Clara.)								

Date.	Character.	Phase.	Time.	Period. T.	Amplitude. A_E	Amplitude. A_N	Distance.	Remarks.
Colorado. *Denver. Sacred Heart College.* Earthquake Station. A. W. Forstall, S. J.								
Lat., 39° 40′ 36″ N.; long., 104° 56′ 54″ W. Elevation, 1,655 meters.								
Instrument: Wiechert 80 kg., astatic, horizontal pendulum.								
Instrumental constants.....								
1915. Dec. 2	.....	L_N.....	*H. m. s.* 15	*Sec.*	μ	μ	*Km.*	Activity on both components, especially on N-S.
		F.....	18	.....	.....	.....	.....	
11	.....	L_E.....	12 12 00	.....	.....	.....	.....	Small distinct waves.
		F_E.....	12 17 00	.....	.....	.....	.....	
11	.....	L_E.....	12 31 00	.....	.....	.....	.....	Reappearance of small waves.
		F_E.....	12 36 00	.....	.....	.....	.....	
11	.....	L_E.....	15 01 00	.....	.....	.....	.....	Very small, but distinct and regular waves. N-S component disturbed by machinery.
		M_E.....	15 13 00	7-8	8	.....	.....	
		C_E.....	15 28 00	.....	.....	.....	.....	
		F_E.....	15 31 00	.....	.....	.....	.....	
15	.....	L_N.....	8	25-40	.....	.....	.....	Very distinct on N-S, but indistinct on E-W.
		F_E.....	14	.....	.....	.....	.....	
29-30	.....	.....	.....	20-24	.....	9	.....	Very striking activity. Waves were distinct and regular on N-S.
31	.....	L.....	12 27 00	.....	.....	.....	.....	Preliminaries not discernible. Waves much clearer on N-S.
		M_N.....	12 28 00	10	.....	18	.....	
		M_E.....	12 30 00	10	18	.....	.....	
		F_E.....	12 34 00	.....	.....	.....	.....	
		F_N.....	12 37 00	.....	.....	.....	.....	
District of Columbia. *Washington. U. S. Weather Bureau.*								
Lat., 38° 54′ 12″ N.; long., 77° 03′ 03″ W. Elevation, 21 meters.								
Instrument: Marvin (vertical pendulum, undamped. Mechanical registration.)								
Instrumental constants.. V=110 T_0=6								
1915. Dec. 7	I_n.....	P.....	*H. m. s.* 10 46 44	*Sec.*	μ	μ	*Km.* 5,085	
		S.....	10 53 31	.....	.....	.....	.....	
		L.....	10 59 40	.....	.....	.....	.....	
		F.....	11 25 00	.....	.....	.....	.....	
7	I_r.....	P?.....	18 43 18	.....	.....	.....	1,180	Near Cairo, Ill. Waves with a period of 1 second superimposed on secondary.
		S.....	18 45 24	.....	.....	.....	.....	
		L.....	18 46 28	.....	.....	.....	.....	
12	I_r.....	P.....	21 08 32	.....	.....	.....	4,200	Strong microseisms prevailed. L uncertain, F lost in microseisms.
		S.....	21 14 30	.....	.....	.....	.....	
28	I_n.....	P.....	23 48 00	.....	.....	.....	5,965	
		S.....	23 55 34	.....	.....	.....	.....	
29		L?.....	0 03 05	.....	.....	.....	.....	F lost in microseisms.
31	I_r.....	P.....	12 27 09	.....	.....	.....	3,980	
		S.....	12 32 55	.....	.....	.....	.....	
		L?.....	12 39 03	.....	.....	.....	.....	
		F?.....	13 30 ..	.....	.....	.....	.....	F merges in microseisms.
31	I_r.....	P.....	23 13 14	.....	.....	.....	3,055	
		S.....	23 18 15	.....	.....	.....	.....	
		L?.....	23 23 09	.....	.....	.....	.....	
		F?.....	23 40 ..	.....	.....	.....	.....	F merges in microseisms.

TABLE 2.—*Instrumental seismological reports, December, 1915*—Continued.

Date.	Character.	Phase.	Time.	Period. T.	Amplitude. A_E	Amplitude. A_N	Distance.	Remarks.
			H. m. s.	*Sec.*	μ	μ	*Km.*	
District of Columbia. *Washington. Georgetown University.* F. L. Tondorf, S. J.								
Lat., 38° 54′ 25″ N.; long., 77° 04′ 24″ W. Elevation, 42.4 meters. Subsoil. Decayed diorite.								
Instruments: Wiechert 200 kg. astatic horizontal pendulums, 80 kg. vertical.								
Instrumental constants:			*V*	T_0	*e*			
		E	165	5.4	2.6			
		N	143	5.2	3.4			
		Z	80	*3.0*	*0*			
1915. Dec. 7	.....	eP_E?..	18 40 57	.....	.....	.....	.....	Heavy microseisms. P and S very doubtful.
		eP_N?..	18 41 23	.....	.....	.....	.....	
		S_E?....	18 44 31	.....	.....	.....	.....	Reported from Cairo, Ill.
		S_N?....	18 45 05	.....	.....	.....	.....	
		L_N....	18 45 28	5	.....	.....	.....	
		L_E....	18 45 30	5	.....	.....	.....	
		M_N....	18 45 35	.....	.....	6	.....	No distinct M_E.
		F.....	19 15 00	.....	.....	.....	.....	
12	II_r	iP_N...	21 08 32	.....	.....	.....	.....	Heavily masked by microseisms. No distinct maximum.
		eP_E...	21 08 37	.....	.....	.....	.....	
		S_N?...	21 12 21	.....	.....	.....	.....	
		S_E.....	21 12 30	.....	.....	.....	.....	
		L_E....	21 14 37	15	.....	.....	.....	
		eL_N...	21 15 58	15	.....	.....	.....	
		F.....	21 40 00	.....	.....	.....	.....	
31	II_r	eP....	12 30 48	.....	.....	.....	.....	Phases masked by microseisms. E-W illegible.
		eL_N...	12 40 13	20	.....	.....	.....	
		M_N....	12 44 20	.....	.....	6	.....	Mainka seismograph shows eP at $12^h\ 20^m\ 13^s$.
		F.....	13 05 00	.....	.....	.....	.....	Gram poor because of poor paper accidentally used.
Hawaii. *Honolulu. Magnetic Observatory.* U. S. Coast and Geodetic Survey. Wm. W. Merrymon.								
Lat., 21° 19′ 12″ N.; long., 158° 03′ 48″ W. Elevation, 15.2 meters.								
Instrument: Milne seismograph of the Seismological Committee of the British Association.								
Instrumental constant..				T_0 18.8				
1915. Dec. 3	.....	P.....	3 03 30	.....	.....	.....	.....	
		S.....	3 17 00	.....	.....	.....	.....	
		L.....	3 28 00	21	.....	.....	.....	
		M.....	3 33 24	.....	*300	.....	.....	
		C.....	3 43 00	.....	.....	.....	.....	
		F.....	5 09 00	.....	.....	.....	.....	
6	.....	P.....	21 15 18	.....	.....	.....	.....	
		L.....	21 23 42	22	.....	.....	.....	
		M.....	21 27 18	.....	*200	.....	.....	
		C.....	21 32 18	.....	.....	.....	.....	
		F.....	21 48 48	.....	.....	.....	.....	
9	.....	L.....	13 42 36	24	.....	.....	.....	
		M.....	13 47 36	.....	*500	.....	.....	
		C.....	13 52 12	.....	.....	.....	.....	
		F.....	14 29 18	.....	.....	.....	.....	
14	.....	e.....	8 16 24	24	.....	.....	.....	
		M.....	8 21 18	.....	*100	.....	.....	
		F.....	8 33 30	.....	.....	.....	.....	
17	.....	P.....	7 44 00	.....	.....	.....	.....	
		S.....	7 52 06	.....	.....	.....	.....	
		L.....	8 00 36	22	.....	.....	.....	
		M.....	8 01 42	.....	*200	.....	.....	
		C.....	8 18 54	.....	.....	.....	.....	
		F.....	8 55 48	.....	.....	.....	.....	
19	.....	e.....	21 07 00	.....	.....	.....	.....	Not well defined.
		M.....	21 14 12	.....	*100	.....	.....	
		C.....	21 19 42	.....	.....	.....	.....	
		F.....	22 34 48	.....	.....	.....	.....	

*Trace amplitude.

Date.	Character.	Phase.	Time.	Period. T.	Amplitude. A_E	Amplitude. A_N	Distance.	Remarks.
			H. m. s.	*Sec.*	μ	μ	*Km.*	
Hawaii. *Honolulu. Magnetic Observatory*—Continued.								
1915. Dec. 21	.....	e.....	9 32 54	.....	.....	.....	.....	
		M.....	9 36 18	.....	*100	.....	.....	
		F.....	9 41 12	.....	.....	.....	.....	
22	.....	e.....	12 04 24	.....	.....	.....	.....	
		M.....	12 09 06	.....	*100	.....	.....	
		F.....	12 28 00	.....	.....	.....	.....	
27	.....	L.....	4 35 18	24	.....	.....	.....	
		M.....	4 44 00	.....	*400	.....	.....	
		C.....	4 47 54	.....	.....	.....	.....	
		F.....	5 12 36	.....	.....	.....	.....	
29	.....	e.....	0 08 24	.....	.....	.....	.....	
		M.....	0 25 12	.....	*100	.....	.....	
		F.....	0 33 12	.....	.....	.....	.....	
29	.....	e.....	22 16 00	.....	.....	.....	.....	
		M.....	22 19 30	.....	*100	.....	.....	
		F.....	22 28 00	.....	.....	.....	.....	
31	.....	P.....	12 27 54	.....	.....	.....	.....	
		S.....	12 30 48	.....	.....	.....	.....	
		L.....	12 34 06	20	.....	.....	.....	
		M.....	12 37 42	.....	*2,000	.....	.....	
		C.....	12 45 12	.....	.....	.....	.....	
		F.....	13 58 36	.....	.....	.....	.....	
31	.....	P.....	23 02 42	.....	.....	.....	.....	
		S.....	23 05 54	.....	.....	.....	.....	
		L.....	23 08 48	21	.....	.....	.....	
		M.....	23 17 42	.....	*400	.....	.....	
		C.....	23 23 48	.....	.....	.....	.....	
Jan. 1 (1916).		F.....	0 03 18	.....	.....	.....	.....	

*Trace amplitude.

Kansas. *Lawrence. University of Kansas.* Department of Physics and Astronomy. F. E. Kester.

Lat., 38° 57′ 30″ N.; long., 95° 14′ 58″ W. Elevation, 301.1 meters.

Instrument: Wiechert.

Instrumental constants..		*V*	T_0	*e*
	E	177	3.4	4
	N	205	3.4	4

1915. Dec. 7	.....	P.....	18 41 25	.....	2	1	.....	Press reports located Cairo, Ill.
		S_N?...	18 42 10	.....	.....	.....	.....	S not discernible on E-W.
		L.....	18 42 29	.....	.....	.....	.....	
		M.....	18 42 45	.....	11	13	.....	
		F.....	18 59 00	.....	.....	.....	.....	
11–12	.....	.....	.....	.....	.....	.....	.....	Strong microseisms prevailed in continually recurring trains of waves, generally smooth sine curves from 3 or 4 up to 12 or more waves in a train with periods of 5 or 6 seconds. Strongly suggestive of Wiechert standing waves within a definite thickness of earth's crust.
12	.....	P.....	21 09 15	2–3	1	1	.....	S_E and L_E not discernible.
		S_N....	21 13 38	5–10	.....	2	.....	
		L_N? ..	21 18 34	.....	.....	.....	.....	
		M_E....	21 19 15	8–10	3	.....	.....	
		M_N....	21 19 30	8–10	.....	2	.....	
		F.....	.....	.....	.....	.....	.....	F in microseisms.
31	.....	P_E....	12 25 09	3–4	1	.....	.....	
		P_N....	12 25 10	.....	.....	.....	.....	Apparently due to E-W motion of pendulum.
		S_N....	12 29 33	3–6	.....	.....	.....	
		S_E....	12 29 35	.....	.....	.....	.....	
		L_N....	12 33 33	.....	.....	.....	.....	L_E?.
		M_N....	12 34 00	12–15	.....	3	.....	
		M_E....	12 35 00	12–15	6	.....	.....	
		F.....	13 17 00	.....	.....	.....	.....	

TABLE 2.—*Instrumental seismological reports, December, 1915*—Continued.

Maryland. *Cheltenham. Magnetic Observatory.* U. S. Coast and Geodetic Survey. George Hartnell.

Lat., 38° 44′ 00″ N.; long., 76° 50′ 30″ W. Elevation, 71.6 meters.

Instruments: Two Bosch-Omori, 10 and 12 kg.

Instrumental constants.. V: E 10, N 10; T_0: 31, 29

Date.	Character.	Phase.	Time.	Period. T.	Amplitude. A_E	Amplitude. A_N	Distance.	Remarks.
			H. m. s.	*Sec.*	μ	μ	*Km.*	
1915. Dec. 7	.....	P_N	18 45 24	3	.....	.....	.....	
		P_E	18 45 27	3	.....	.....	.....	
		L_N	18 45 36	.....	.....	.....	.....	
		M	18 45 45	.....	10	20	.....	
		C	18 47 00	.....	.....	.....	.....	
		F	18 49 00	.....	.....	.....	.....	
12	.....	P_N	21 08 08	3	.....	.....	.....	Beginning and end confused by wind tremors.
		L_E	21 14 37	7	.....	.....	.....	
		L_N	21 15 14	7	.....	.....	.....	
		M_N	21 16 57	10	.....	60	.....	
		M_E	21 17 40	9	50	.....	.....	
		C_N	21 19 00	7	.....	.....	.....	
		F_N	21 31 00	.....	.....	.....	.....	
31	.....	L_N	12 41 09	13	.....	.....	.....	Phases not well defined, particularly at the beginning.
		L_E	12 41 14	12	.....	.....	.....	
		M_N	12 41 24	16	.....	60	.....	
		M_E	12 43 18	16	80	.....	.....	
		C	12 47 00	10	.....	.....	.....	
		F	13 05 00	.....	.....	.....	.....	

Massachusetts. *Cambridge. Harvard University Seismographic Station,* J. B. Woodworth.

Lat., 42° 22′ 36″ N.; long., 71° 06′ 59″ W. Elevation, 5.4 meters. Foundation: Glacial sand over clay.

Instruments: Two Bosch-Omori 100 kg. horizontal pendulums (mechanical registration).

Instrumental constants.. V: E 80, N 50; T_0: 23, 25; ε: 0, 4:1

Date.	Character.	Phase.	Time.	Period. T.	Amplitude. A_E	Amplitude. A_N	Distance.	Remarks.
			H. m. s.	*Sec.*	μ	μ	*Km.*	
1915. Dec. 3	.....	e?	.. .. ..	.....	.....	.....	.....	E–W record entangled.
		L_N	3 43 10	25	.....	.....	.....	
		L	3 47 00	20	.....	.....	.....	
		F	4 06 00	.....	.....	.....	.....	
6	.....	*O*?	*20 60 00*	.....	.....	.....	*16,900*?	
		e?	21 30 35	.....	.....	.....	.....	P and S masked by microseisms. Distance from LR1—eL_E = 30.75 mins. Distance = 20,000 minus 30.75/2×202 Km. Amplitude decreases suddenly at 21h 52m 28s.
		eL_E	21 49 15	.....	.....	.....	.....	
		L	21 50 30 / 21 52 28	20	.....	.....	.....	
		LR1	22 20 00 / 22 22 22	12	.....	.....	.....	
		P	22 59 00	.....	.....	.....	.....	
7	.....	*O*	*10 38 26*	.....	.....	.....	*4,500*	
		P_E	10 46 20	.....	.....	.....	.....	
		S	10 52 37	6	.....	.....	.....	
		L	10 57 08	20	.....	.....	.....	
		F	11 28 00	.....	.....	.....	.....	
7	.....	*O*?	*12 30 25*	.....	.....	.....	*2,480*?	
		iP	12 35 28	.....	.....	.....	.....	
		S?	12 39 40	.....	.....	.....	.....	
		eL	12 41 36	.....	.....	.....	.....	eL possibly P of another quake?
		L	12 53 34	16	.....	.....	.....	
		L	13 10 02 / 13 11 39	10	.....	.....	.....	F lost in microseisms. Sheets changed at 13h 35m 30s.
7	.....	*O*?	*18 40 00*	.....	.....	.....	.....	*O* from St. Louis records. Reported near Cairo, Ill., by St. Louis Observatory.
		iP	18 43 35	.....	.....	.....	.....	
		L_E	18 47 50	.....	.....	.....	.....	
		L_N	18 48 14	.....	.....	.....	.....	
		F	18 50 00	.....	.....	.....	.....	
8	.....	e?	18 25 53	11	.....	.....	.....	Record of doubtful character. Preceded and followed by similar disturbances.
			18 33 46	70	.....	.....	.....	
				36	.....	.....	.....	
				62	.....	.....	.....	
			18 39 05	26	.....	.....	.....	
			18 44 14 / 18 45 24	15	.....	.....	.....	F indeterminate.

O—time at origin.

Massachusetts. *Cambridge. Harvard University Seismographic Station*—Continued.

Date.	Character.	Phase.	Time.	Period. T.	Amplitude. A_E	Amplitude. A_N	Distance.	Remarks.
			H. m. s.	*Sec.*	μ	μ	*Km.*	
1915. Dec. 12	.....	*O*	*21 02 01*	.....	.....	.....	*4,000*	Except P_N, record much masked by microseisms.
		P_N	21 09 19	3	.....	.....	.....	
		iP	21 09 35	4	.....	.....	.....	iP, steady mass thrown south.
		eP_E?	21 10 34	.....	.....	.....	.....	
		S_N	21 15 06	.....	.....	.....	.....	
		S_E	21 15 23	.....	.....	.....	.....	
		L_N	21 18 20	.....	.....	.....	.....	
		L_E	21 18 22	.....	.....	.....	.....	
		F	21 35 30	.....	.....	.....	.....	
17	.....	L_E	5 57 29	16	.....	.....	.....	Masked by microseisms.
		F	5 58 31	.....	.....	.....	.....	
17	.....	*O*?	*7 40 21*	.....	.....	.....	*4,345*?	e–S? Distance from S–L?
		e	7 54 11	.....	.....	.....	.....	
		L_E	7 58 30	20	.....	.....	.....	L not registered on N–S.
		F	8 15 12	.....	.....	.....	.....	
18	.....	L_E	.. .. ..	.....	.....	.....	.....	Between 14h and 21h a group of long waves beginning about 4 mins. past the hour; undeterminable because of entangled lines.
19	.....	L_E?	21 23 00	.....	.....	.....	.....	
		F	21 44 00	.....	.....	.....	.....	
29	.....	L_E?	0 12 34	.....	.....	.....	.....	e earlier? Phases masked by microseisms.
		F?	0 17 58	.....	.....	.....	.....	
31	.....	*O*?	*12 19 23*	.....	.....	.....	*4,810*	*O* from S–eL. Readings for P and S unreliable.
		eP?	12 27 38	.....	.....	.....	.....	
		R	12 28 57	.....	.....	.....	.....	
		S_E	12 33 53	.....	.....	.....	.....	
		S_N	12 34 00	.....	.....	.....	.....	
		eL_N	12 40 25	.....	.....	.....	.....	
		L_E	12 41 13	10–12	.....	.....	.....	
		M_E	12 45 03	16–14	.....	.....	.....	
		F?	13 42 00	.....	.....	.....	.....	F lost in changing records.

O—time at origin.

Missouri. *Saint Louis. St. Louis University.* Geophysical Observatory. J. B. Goesse, S. J.

Lat., 38° 38′ 15″ N.; long., 90° 13′ 58″ W. Elevation, 160.4 meters. Foundation: 12 feet of tough clay over limestone of Mississippi system, about 300 feet thick.

Instrument: Wiechert 80 kg. astatic, horizontal pendulum.

Instrumental constants.. V: 80; T_0: 7; ε: 5:1

Date.	Character.	Phase.	Time.	Period. T.	Amplitude. A_E	Amplitude. A_N	Distance.	Remarks.
			H. m. s.	*Sec.*	μ	μ	*Km.*	
1915. Dec. 7	III_T	iP	18 40 42	.....	.....	.....	184?	Reported principally from Cairo, Ill.
		eP_E	18 40 48	.....	.....	.....	.....	
		S_N	18 41 06	.....	.....	.....	.....	
		S_E	18 41 12	.....	.....	.....	.....	
		M_E	18 41 30	.....	41	.....	.....	
		M_N	18 41 36	.....	.....	28	.....	
		F	18 58 00	.....	.....	.....	.....	
12	II_T	iP	21 14 00	.....	.....	.....	1,600	
		S_N	21 16 18	.....	.....	.....	.....	
		S_E	21 16 30	.....	.....	.....	.....	
		L_N	21 17 00	.....	.....	.....	.....	
		L_E	21 17 12	.....	.....	.....	.....	
		M_E	21 17 42	7	24	.....	.....	
		M_N	21 18 06	7	.....	45	.....	F lost in microseisms.
31	II_U	eP	12 30 30	.....	.....	.....	6,300?	
		S_N	12 35 00	.....	.....	.....	.....	
		S_E	12 35 12	.....	.....	.....	.....	
		L_N	12 35 42	.....	.....	.....	.....	
		L_E	12 37 06	.....	.....	.....	.....	
		M_N	12 36 12	10	.....	50	.....	
		M_E	12 37 18	10	25	.....	.....	F lost in microseisms. Microseisms continuous from 2h 37m of Dec. 28, 1915, to Jan. 1, 1916.

TABLE 2.—*Instrumental seismological reports, December, 1915*—Continued.

New York. *Buffalo. Canisius College.* John A. Curtin, S. J.

Lat., 42° 53′ 02″ N.; long., 78° 52′ 40″ W. Elevation, 190.5 meters.

Instrument: Wiechert 80 kg. horizontal.

Instrumental constants.. V 80, T_0 7, ϵ 5:1

Date.	Character.	Phase.	Time.	Period. T.	Amplitude. A_E	Amplitude. A_N	Distance.	Remarks.
			H. m. s.	*Sec.*	μ	μ	*Km.*	
1915. Dec. 7	I_r	i_E	18 48 20		20			A sudden shock from the southwest, followed by microseisms.
		i_N	18 48 30		10		25	
		F_E	13 49 25					
		F_N	13 49 45					
12	I_r	eP_E	21 16 10					Preceded by microseism for 24 hours and followed by same for 8 hours.
		S_E	21 19 40					N-S masked by microseisms.
		M_E	21 22 10		15	20		
		F_E	21 27 00					
31	II_r	eP_N	12 29 45					Preliminary tremors for 48 hours. S masked by microseisms.
		eP_E	12 31 45					
		L_N	12 41 00					
		L_E	12 43 00					
		M_N	12 42 00		12		25	Reported in Honduras.
		M_E	12 44 00		20			
		F_N	12 59 00					
		F_E	13 01 00					

New York. *Fordham. Fordham University.* W. C. Repetti, S. J.

Lat., 40° 57′ 47″ N.; long., 73° 53′ 08″ W. Elevation, 23.9 meters.

Instrument: Wiechert 80 kg.

Instrumental constants.. V (E 72, N 73), T_0 7.2, ϵ (E 1.5, N 3.75)

(Report for December, 1915, not received.)

Panama Canal Zone. *Balboa Heights.* Isthmian Canal Commission.

Lat., 8° 57′ 39″ N.; long., 79° 33′ 29″ W. Elevation, 27.6 meters.

Instruments: Two Bosch-Omori 100 kg.

Instrumental constants.. V 10, T_0 20

Date.	Character.	Phase.	Time.	Period. T.	Amplitude. A_E	Amplitude. A_N	Distance.	Remarks.
			H. m. s.	*Sec.*	μ	μ	*Km.*	
1915. Dec. 5	.....	P_E	1 23 45				227	Direction probably SW?
		P_N	1 24 00					
		L_E	1 24 11					
		M_E	1 24 17		150			
		L_N	1 24 26					
		M_N	1 24 34			200		
		F_E	1 26 10					
		F_N	1 26 30					
12	.....	P	21 06 00				1,635	Direction probably northerly.
		S_N	21 08 20					
		S_E	21 08 22					
		M_E	21 08 30		60			
		L_N	21 10 50					
		L_E	21 11 00					
		M_N	21 11 10			100		
		F_E	21 22 30					
		F_N	21 28 45					

Panama Canal Zone. *Balboa Heights*—Continued.

Date.	Character.	Phase.	Time.	Period. T.	Amplitude. A_E	Amplitude. A_N	Distance.	Remarks.
			H. m. s.	*Sec.*	μ	μ	*Km.*	
1915. Dec. 15	.....	P	14 19 05				227	Direction SW?
		L	14 19 31					
		M_E	14 19 34		1,100			
		M_N	14 19 45			750		
		F	14 26 00					
15	.....	P	19 22 12				212	Direction SW.? Record on E–W. lost, account of clock stopping.
		L	19 22 36					
		M	19 22 38			800		
		F	19 28 00					
26	.....	L	23 21 17					Distance and direction, unknown, probably NW.
		M_E	23 21 35		20			
		M_N	23 21 41			20		
		F	(?)					
28	.....	P_E	23 44 21				1,530	Direction probably NW.
		P_N	23 44 25					
		L_E	23 48 53					
		L_N	23 49 00					
		M_E	23 49 25		80			
		M_N	23 50 07			100		
29	.....	F_E	0 03 40					
		F_N	0 06 20					
30	.....	P_N	6 45 33				644	Direction probably NW?
		P_E	6 45 34					
		L_N	6 46 50					
		L_E	6 46 55					
		M_N	6 47 00			50		
		M_E	6 47 15		50			
		F_E	6 54 10					
		F_N	6 55 20					

Porto Rico. *Vieques. Magnetic Observatory.* U. S. Coast and Geodetic Survey. H. M. Pease.

Lat. 18° 09′ N.; long., 65° 27′ W. Elevation, 19.8 meters.

Instruments: Two Bosch-Omori.

Instrumental constants.. V (E 10, N 10), T_0 (E 21.4, N 21.1)

Date.	Character.	Phase.	Time.	Period. T.	Amplitude. A_E	Amplitude. A_N	Distance.	Remarks.
			H. m. s.	*Sec.*	μ	μ	*Km.*	
1915. Dec. 12	.....	eL	21 10 57	20				Only a few long waves.
		M	21 13 53	15	20	40		
		C	21 21 00	11				

Vermont. *Northfield. U. S. Weather Bureau.* Wm. A. Shaw.

Lat., 44° 10′ N.; long., 72° 41′ W. Elevation, 256 meters.

Instruments: Two Bosch-Omori, mechanical registration.

Instrumental constants: V (E 10, N 10), T_0 (E 15, N 16)

Date.	Character.	Phase.	Time.	Period. T.	Amplitude. A_E	Amplitude. A_N	Distance.	Remarks.
			H. m. s.	*Sec.*	μ	μ	*Km.*	
1915 Dec. 7	.....	L	10 58 30					Very feeble long waves.
7	.....							Feeble disturbance from $18^h\ 40^m$ to $18^h\ 50^m$. Phases indistinct.
12	.....	L	21 18 42	16				Other phases uncertain and confused in microseisms.
		F	21 30 00					
31	.....	L	12 39 47					P and S not discernible.
		F	13 15 00					

TABLE 2.—*Instrumental seismological reports, December, 1915*—Continued.

Canada. *Ottawa. Dominion Astronomical Observatory.* Earthquake Station. Otto Klotz.

Lat., 45° 23′ 38″ N.; long., 75° 42′ 57″ W. Elevation, 83 meters.

Instruments: Two Bosch photographic horizontal pendulums, one Spindler & Hoyer 80 kg. vertical seismograph.

Instrumental constants: V 120, T_0 26

Date.	Character.	Phase.	Time.	Period. T.	Amplitude. A_E	Amplitude. A_N	Distance.	Remarks.
			H. m. s.	*Sec.*	μ	μ	*Km.*	
1915 Dec. 3	.....	P_N?...	3 12 32	.....	.....	.....	7,500?	Phases masked by strong microseisms.
		eL_E...	3 34 42	30	.....	.....	.....	
		L_E....	3 43 00	20	.....	.....	.....	
		L_N....	3 47 00	20	.....	.....	.....	
		L_E....	3 53 00	18	.....	.....	.....	
		F.....	4 10 00	.....	.....	.....	.....	
7	.....	P.....	10 47 07	2	.....	.....	5,340	Phases masked by strong microseisms.
		S_E....	10 54 06	.....	.....	.....	.....	
		S_N....	10 54 10	.....	.....	.....	.....	
		eL.....	10 59 42	18	.....	.....	.....	
		L_E....	11 04 00	16	.....	.....	.....	
		L_E....	11 11 00	14	.....	.....	.....	
		F.....	11 30 00	.....	.....	.....	.....	
7	.....	P.....	18 47 16	2	.....	.....	700	
		S.....	18 48 33	.....	.....	.....	.....	
		F.....	18 55 00	.....	.....	.....	.....	
12	.....	P.....	21 10 25	.....	.....	.....	3,240	Exceedingly strong microseisms present.
		S.....	21 15 25	.....	.....	.....	.....	
		eL.....	21 18 30	38	.....	.....	.....	
		F.....	21 45 00	.....	.....	.....	.....	
17	.....	S_E?...	7 55 04	.....	.....	.....	3,300?	
		eL.....	7 58 00	20	.....	.....	.....	
		L.....	8 02 16	.....	.....	.....	.....	
		F.....	8 15 00	.....	.....	.....	.....	
28	.....	P_N?...	23 51 33	.....	.....	.....	3,800?	Phases masked by very strong microseisms.
		S_E?...	23 57 08	.....	.....	.....	.....	
29		eL_E...	0 09 00	24	.....	.....	.....	
31	.....	P_E....	12 27 03	2	.....	.....	4,000	Phases masked by very strong microseisms.
		$PR2_E$..	12 28 27	.....	.....	.....	.....	
		S_E....	12 32 50	.....	.....	.....	.....	
		L.....	12 38 00	40	.....	.....	.....	
		M_N...	{12 40 42 / 12 41 24}	.....	.....	130	.....	
		M_E...	12 42 24	.....	70	.....	.....	
		F.....	13 30 00	.....	.....	.....	.....	
31	.....	P_E....	23 13 34	2	.....	.....	3,200	N-S component masked by microseisms.
		S_E....	23 18 32	.....	.....	.....	.....	
		$SR1_E$..	23 19 38	.....	.....	.....	.....	
		L_E....	23 22 36	28	.....	.....	.....	
		F.....	23 50 00	.....	.....	.....	.....	

Canada. *Toronto. Dominion Meteorological Service.*

Lat., 43° 40′ 01″ N.; long., 79° 23′ 54″ W. Elevation, 113.7 meters. Subsoil: Sand and clay.

Instrument: Milne horizontal pendulum, North. In the meridian.

Instrumental constant.. T_0 18. Pillar deviation, 1 mm. swing of boom=0.59″.

Date.	Character.	Phase.	Time.	Period. T.	Amplitude. A_E	Amplitude. A_N	Distance.	Remarks.
1915. Dec. 3	.....	L.....	*H. m. s.* 3 35 30	*Sec.*	μ *200	μ	*Km.*	Air currents going on.
7	.....	S?.....	10 55 48	.....	.....	.....	.....	Air currents going on.
		iL.....	11 06 30	.....	*300	.....	.....	
		F.....	11 36 18	.....	.....	.....	.....	
7	.....		.....	.....	.....	.....	.....	Marked air currents going on from 12^h 18^m 24^s to 14^h 39^m.
7	.....	L.....	18 46 30	.....	*50	.....	.....	Air currents going on.
		F?.....	18 54 06	.....	.....	.....	.....	
12	.....	P?.....	21 09 00	.....	.....	.....	.....	Air currents going on before and after principal movements.
		S.....	21 13 30	.....	.....	.....	.....	
		L.....	21 14 42	.....	.....	.....	.....	
		L.....	21 17 36	.....	.....	.....	.....	
		M.....	21 19 00	.....	*1,700	.....	.....	
		F.....	21 53 30	.....	.....	.....	.....	
17	.....	iP.....	7 52 30	.....	.....	.....	.....	Suspicion of air currents about time of iP.
		S or L..	7 58 54	.....	.....	.....	.....	
		L.....	8 01 42	.....	.....	.....	.....	
		M.....	8 04 48	.....	*300	.....	.....	F lost in air currents.
18	.....	L.....	19 08 00	.....	*200	.....	.....	Gradual beginning and ending.
		F.....	19 14 54	.....	.....	.....	.....	

* Trace amplitude.

Canada. *Toronto. Dominion Meteorological Service*—Continued.

Date.	Character.	Phase.	Time.	Period. T.	Amplitude. A_E	Amplitude. A_N	Distance.	Remarks.
1915. 28	.....	P.....	*H. m. s.* 23 51 24	*Sec.*	μ	μ	*Km.*	
		S.....	23 56 36	.....	.....	.....	.....	
29		L.....	0 04 00	.....	.....	.....	.....	
		M.....	0 04 24	.....	*300	.....	.....	
		L.....	0 10 00	.....	.....	.....	.....	F lost in air currents.
31	.....	P?.....	12 28 00	.....	.....	.....	.....	
		S.....	12 31 54	.....	.....	.....	.....	
		L.....	12 35 48	.....	.....	.....	.....	
		L.....	12 38 12	.....	.....	.....	.....	
		M.....	12 40 30	.....	*1,800	.....	.....	
		F.....	13 23 54	.....	.....	.....	.....	
31	.....	P.....	23 13 18	.....	.....	.....	.....	
		S.....	23 21 18	.....	.....	.....	.....	
		L.....	23 24 42	.....	.....	.....	.....	
		M.....	23 26 36	.....	*300	.....	.....	
1		F.....	0 12 06	.....	.....	.....	.....	

* Trace amplitude.

Canada. *Victoria, B. C. Dominion Meteorological Service.*

Lat., 48° 24′ N.; long., 123° 19′ W. Elevation, 67.7 meters. Subsoil: Rock.

Instrument: Wiechert, vertical; Milne horizontal pendulum, North. In the meridian.

Instrumental constant.. T_0 18. Pillar deviation, 1 mm. swing of boom=0.54″.

Date.	Character.	Phase.	Time.	Period. T.	Amplitude. A_E	Amplitude. A_N	Distance.	Remarks.
1915. Dec. 3	.....	P.....	*H. m. s.* 3 31 23	*Sec.*	μ	μ	*Km.* 2,040	
		S.....	3 34 51	.....	.....	.....	.....	
		L.....	3 38 19	.....	.....	.....	.....	
		M.....	3 40 18	.....	*500	.....	.....	
		F.....	3 53 12	.....	.....	.....	.....	
7	.....	P.....	11 08 41	.....	.....	.....	.....	
		S.....	11 14 08	.....	.....	.....	.....	
		L.....	11 18 07	.....	.....	.....	.....	
		M.....	11 22 05	.....	*200	.....	.....	
		F.....	11 50 20	.....	.....	.....	.....	
7	.....	P?.....	12 25 33	.....	.....	.....	.....	
		S.....	?	.....	.....	.....	.....	
		L.....	?	.....	.....	.....	.....	
		M.....	12 27 02	.....	*200	.....	.....	
		F.....	12 50 20	.....	.....	.....	.....	
12	.....	P or S.	21 32 56	.....	.....	.....	.....	
		L.....	21 41 26	.....	.....	.....	.....	
		M.....	21 42 26	.....	*200	.....	.....	
		F.....	21 48 26	.....	.....	.....	.....	
17	.....	P or S.	7 51 31	.....	.....	.....	.....	
		L.....	7 59 31	.....	.....	.....	.....	
		M.....	8 03 01	.....	*200	.....	.....	
		F.....	8 11 01	.....	.....	.....	.....	
18	.....	L.....	19 28 00	.....	*50	.....	.....	Not well defined.
		F.....	19 34 36	.....	.....	.....	.....	
28	.....	P or S.	23 58 22	.....	.....	.....	.....	
29		L.....	0 00 52	.....	.....	.....	.....	
		M.....	0 01 22	.....	*300	.....	.....	
		F.....	0 07 22	.....	.....	.....	.....	
29	.....	P.....	?	.....	.....	.....	.....	
		S.....	?	.....	.....	.....	.....	
		L.....	0 16 45	.....	.....	.....	.....	
		M.....	0 24 45	.....	*200	.....	.....	
		F.....	0 38 15	.....	.....	.....	.....	
31	.....	P.....	12 20 47	.....	.....	.....	830	Eureka, Cal.
		S.....	12 22 17	.....	.....	.....	.....	
		L.....	12 25 17	.....	.....	.....	.....	
		M.....	12 26 17	.....	*1,400	.....	.....	
		F.....	13 25 17	.....	.....	.....	.....	
			VERTICAL.		A_E			
		P.....	*12 21 18*	*6*	.....	.....	.....	
		S.....	*12 22 54*	*8*	.....	.....	.....	
		L.....	*12 23 34*	*17*	.....	.....	.....	
		M.....	*12 27 44*	.....	*40*	.....	.....	
		F.....	*13 09 44*	.....	.....	.....	.....	
31	.....	P?.....	23 15 57	.....	.....	.....	.....	
		S?.....	?	.....	.....	.....	.....	
		L.....	23 16 27	.....	.....	.....	.....	
		M.....	23 21 27	.....	*400	.....	.....	
		F.....	23 49 27	.....	.....	.....	.....	
			VERTICAL.		A_E			
		P.....	*23 05 54*	*2*	.....	.....	*1,160*	
		S.....	*23 07 38*	*3–5*	.....	.....	.....	
		L.....	*23 15 06*	.....	.....	.....	.....	
		M.....	*23 16 34*	.....	*1*	.....	.....	

* Trace amplitude.

TABLE 3.—*Late seismological reports.* (*Instrumental.*)

Canada. *Toronto. Dominion Meteorological Service.*

Lat., 43° 40′ 01″ N.; long., 79° 23′ 54″ W. Elevation, 113.7 meters. Subsoil: Sand and clay.

Instrument: Milne horizontal pendulum, North. In the meridian.

Instrumental constant..$T_0$18. Pillar deviation, 1 mm. swing of boom=0.59″.

Date.	Character.	Phase.	Time.	Period. T.	Amplitude. A_E	Amplitude. A_N	Distance.	Remarks.
			H. m. s.	*Sec.*	μ	μ	*Km.*	
1915. Nov. 1	.....	iP.....	7 47 48	.....	*1,100	.....	11,766	P well defined. A well-defined disturbance. Boom fairly steady from 8h 9m 48s to 8h 10m 18s.
		iS.....	8 00 00	.....	.....	.....	.....	
		iL.....	8 10 18	12	*1,000	.....	.....	
		L.....	8 13 18	12	.....	.....	.....	
		L.....	8 14 18	.....	*4,000	.....	.....	
		L.....	8 17 12	.....	.....	.....	.....	
		L.....	8 19 12	.....	.....	.....	.....	
		M.....	8 24 12	18	*8,000	.....	.....	
		L.....	8 27 18	.....	.....	.....	.....	
		L.....	8 32 48	.....	.....	.....	.....	Trailers and F merge into succeeding quake.
1	.....	S or L.	9 46 48	.....	.....	.....	.....	Possibly a dual earthquake.
		iL.....	9 53 54	.....	.....	.....	.....	
		M.....	10 00 36	.....	*1,000	.....	.....	
		C.....	10 05 42	.....	.....	.....	.....	
		C or M.	10 07 42	.....	*300	.....	.....	
		L.....	10 21 12	.....	.....	.....	.....	
		F.....	11 23 24	.....	.....	.....	.....	
18	.....	L.....	4 51 36	.....	.....	.....	.....	P, S, and F in air currents.
		L.....	4 56 06	.....	.....	.....	.....	
		M.....	5 04 18	.....	*300	.....	.....	
21	.....	S.....	0 26 06	.....	.....	.....	.....	P not recorded. A well-marked earthquake. Origin in southern California.
		L.....	0 30 54	.....	.....	.....	.....	
		M.....	0 31 48	.....	*5,900	.....	.....	
		M.....	0 33 18 0 33 36	.....	*7,000	.....	.....	
		F?.....	3 08 30	.....	.....	.....	.....	
22	.....	L.....	5 46 48	.....	*100	.....	.....	Gradual thickening. Doubtful as to being seismic.
		F.....	5 48 24	.....	.....	.....	.....	
26	.....	P?.....	19 22 48	.....	.....	.....	.....	P very doubtful, not well defined.
		S or L.	19 29 12	.....	.....	.....	.....	
		L.....	19 31 18	.....	.....	.....	.....	
		L.....	19 34 24	.....	.....	.....	.....	
		M.....	19 35 24	.....	*700	.....	.....	
		F.....	20 01 00	.....	.....	.....	.....	
26	.....	.....	.....	.....	.....	.....	.....	Air currents from 20h 22m 0s to 20h 40m 30s.
30	.....	S?.....	5 03 12	.....	.....	.....	.....	P possibly not recorded. S doubtful, may be a long wave.
		L.....	5 06 54	.....	.....	.....	.....	
		M.....	5 09 00	.....	*800	.....	.....	
		F.....	5 27 00	.....	.....	.....	.....	

* Trace amplitude.

Canada. *Victoria, B. C. Dominion Meteorological Service.*

Lat., 48° 24′ N.; long., 123° 19′ W. Elevation, 67.7 meters. Subsoil: Rock.

Instruments: Wiechert, vertical. Milne horizontal pendulum, North. In the meridian.

Instrumental constant..$T_0$18. Pillar deviation: 1 mm. swing of boom=0.54″.

Date.	Character.	Phase.	Time.	Period. T.	Amplitude. A_E	Amplitude. A_N	Distance.	Remarks.
			H. m. s.	*Sec.*	μ	μ	*Km.*	
1915. Nov. 1	.....	P?.....	7 34 00	.....	.....	.....	7,280	
		S.....	7 42 42	12–18	.....	.....	.....	
		iS?.....	7 46 30	.....	.....	.....	.....	
		L.....	8 00 54	18–24	.....	.....	.....	
		M.....	8 04 54	30	*3,500	.....	.....	
		F.....	11 10 06	.....	.....	.....	.....	
18	.....	P.....	4 41 48	.....	.....	.....	.....	
		L.....	4 44 18	.....	.....	.....	.....	
		M.....	4 44 48	.....	*100	.....	.....	
		F.....	4 49 18	.....	.....	.....	.....	
20	.....	P.....	15 38 54	.....	.....	.....	.....	
		L.....	15 39 54	.....	.....	.....	.....	
		M.....	15 41 24	.....	*100	.....	.....	
		F.....	15 42 54	.....	.....	.....	.....	
21	.....	P.....	0 14 36	.....	.....	.....	1,940	In southern California.
		S.....	0 17 54	.....	.....	.....	.....	
		L.....	0 20 48	.....	.....	.....	.....	
		M.....	0 23 24	.....	*28,000	.....	.....	
		M.....	0 25 18	.....	*17,000	.....	.....	
		F.....	1 00 30	.....	.....	.....	.....	
			VERTICAL.		A_Z.			
		P.....	*0 14 42*	.....	.....	.....	.....	
		S.....	*0 18 06*	.....	.....	.....	.....	
		L.....	*0 20 48*	.....	.....	.....	.....	
		M.....	*0 22 36*	.....	*33	.....	.....	
		F.....	*1 17 00*	.....	.....	.....	.....	
22	.....	L.....	5 42 06	.....	*50	.....	.....	
		F.....	5 43 30	.....	.....	.....	.....	
23	.....	P.....	12 52 42	.....	.....	.....	.....	Very doubtful as to being seismic.
		L.....	12 54 12	.....	.....	.....	.....	
		M.....	12 54 12	.....	*100	.....	.....	
		F.....	12 56 42	.....	.....	.....	.....	
26	.....	L.....	19 45 12	.....	.....	.....	.....	Light very unsteady. Measurements doubtful. No record from 19h 52m 30s, lights off.
		L.....	19 49 54	.....	.....	.....	.....	
30	.....	L.....	5 14 30	.....	.....	.....	.....	Measurements doubtful, light flickered.
		L.....	5 24 18	.....	*50	.....	.....	

* Trace amplitude.

CORRIGENDA.

Instrumental report, Harvard University, MONTHLY WEATHER REVIEW, October, 1915:
Page 525, column 2, line 1: October 11, *0?* should be *19h, 33m, 23s.*
Page 528, column 1, June 23, Remarks *for* "short pre-phases" *read*: "Short period phases."

SEISMOLOGICAL DISPATCHES.[1]

Rome, Dec. 6, 1915, via Paris, 5:10 a. m.

Earthquake shocks were felt at 2 o'clock the morning of the 5th in Latium, at Foli, Frosinone, Genna, Caprino, and Tivoli. There was neither loss of life nor damage of property. (Assoc. Press.)

Cairo, Ill., Dec. 7, 1915.

A severe earthquake shock lasting 90 seconds was felt here at 12:45 p. m. to-day. No damage was reported. (Assoc. press.)

Catania, Sicily, Dec. 17, 1915, 10:35 p. m.

Mount Etna is again showing considerable activity, emitting red-hot lava which, streaming along the side of the mountain and melting the snow, produces a wonderful effect, especially at night. In addition glowing cinders and smoke form an umbrella-shaped cloud above the volcano. (Assoc. Press.)

Guatemala City, Guatemala, Dec. 23, 1915.

There have been 20 severe earthquakes in Guatemala in the last two days. No serious damage has been reported. (Assoc. Press.)

San Salvador, Salvador, via Galveston, Texas, Dec. 29, 1915.

Another earthquake to-day has destroyed what was left standing of the city of Gracias in Honduras. The earthquake of Dec. 27th partly devastated the city, leaving a few buildings standing. Four thousand persons are made homeless by the destruction of the town. Most of them have come to Salvador, which is 70 miles southwest of Gracias. The shocks here, which began on the 27th, have continued at intervals ever since, but have not been nearly so severe as those in the country to the north and east. (Mexican cable to the New York Herald.)

[1] Reported by the organization indicated and collected by the seismological station at Georgetown University, Washington, D. C.

EARTHQUAKES FELT IN THE UNITED STATES DURING 1915.

W. J. HUMPHREYS, Professor in Charge of Seismology.

During 1915, 150 earthquakes strong enough to be fell were reported from different parts of the continentat United States, as listed in the accompanying table, Table 1, and graphically represented (a dot for each report) on W. J. H. figure 1 (XLIII—141), at the end of this issue of the REVIEW.

This graphic scheme, when used on so small a map, does not always distinguish between frequency of shocks and proximity of stations. Nevertheless it gives a general idea of the relative seismicity of the different parts of the country *during the year in question*. Those who wish the facts in greater detail will find them in the annual and monthly tables.

The severest of all these quakes, judging from the area over which it was felt, occurred on October 2, along a fault in Pleasant Valley, Nev. Fortunately the break was so far from towns and thickly settled communities that but little damage was done to property and no loss of life sustained.

The second in severity occurred on June 22, in the Imperial Valley, Cal. Six persons were killed (in Mexicali), many injured, and property damaged to the estimated extent of about $900,000.

Both the above quakes gave large instrumental records at Washington, Ottawa, Sitka, Honolulu, La Paz (Bolivia), and many other distant stations; indeed the vibrations from the Nevada quake appear to have reached all parts of the world.

Four of the sensible earthquakes have been studied in detail and the results published as follows:

"Earthquake at Los Alamos, Cal., Jan. 11," Carl H. Beal, Bulletin of the Seismological Society of America, 5, pp. 14–25.

"The Earthquake in the Imperial Valley, Cal., June 22," Carl H. Beal, Bulletin of the Seismological Society of America, 5, pp. 130–149.

"The Pleasant Valley, Nev., Earthquake of Oct. 2," J. Claude Jones, Bulletin of the Seismological Society of America, 5, pp. 190–205.

"The Earthquake of Oct. 7, in Central California," E. F. Davis, Bulletin of the Seismological Society of America, 5, pp. 230–235.

TABLE 1.—*Places in the United States reporting earthquakes during 1915.*

[Consult also the chart W. J. H. fig. 1, XLIII—141.]

Place.	Approximate latitude.	Approximate longitude.	Number of quakes reported.
ARIZONA.	° ′	° ′	
Mesa	33 24 N.	111 50 W.	1
Parker	34 10	114 16	2
Tucson	32 15	110 50	1
Wickenburg	33 56	112 44	1
Yuma	32 45	114 36	3
ARKANSAS.			
Black Rock	36 08	91 04	1
Blytheville	35 55	89 53	1
Brinkley	34 53	91 07	1
Forest City	35 02	90 43	1
Hardy	36 19	91 22	1
Hunter	35 06	91 05	1
Jonesboro	35 51	90 38	1
Little Rock	34 45	92 06	1
Marion	35 14	90 10	1
Newport	35 36	91 13	1
Ravenden	36 15	91 12	1
Wynne	35 14	90 44	1
CALIFORNIA.			
Aguanga	33 26	116 51	3
Alturas	41 32	120 30	1
Arbolado	36 15	121 47	2
Avalon	33 27	118 22	2
Bakersfield	35 22	119 00	2
Barrett Dam	32 43	116 46	2
Beaumont	33 55	117 00	1
Blythe	33 35	114 38	3
Bonita	32 40	117 03	2
Branscomb	39 40	123 40	1
Brawley	32 59	115 40	13
Bridgeport	38 18	119 15	3

TABLE 1.—*Places in the United States reporting earthquakes during 1915*—Continued.

Place.	Approximate latitude.	Approximate longitude.	Number of quakes reported.
CALIFORNIA—continued.	° ′	° ′	
Cahuilla	33 32	116 43	5
Calexico	32 40	115 28	2
Camino	38 46	120 41	1
Campo	32 38	116 28	1
Camptonville	39 23	121 04	2
Chester	40 18	121 15	2
Chico	39 40	121 40	1
China Flat	40 56	123 30	1
Coalinga	35 19	120 20	1
Coleville	38 36	119 32	3
Colgate	39 22	121 14	1
Colusa	39 12	122 00	1
Converse Nursery	34 04	117 12	1
Corona	33 52	117 35	1
Coulterville	37 42	120 13	2
Coyote	37 14	121 44	3
De Sabla	39 50	121 37	1
Donner	39 17	120 21	1
Drakesbad	40 28	121 29	3
El Cajon	32 48	116 58	4
Eureka	40 48	124 11	3
Fort Bidwell	41 51	120 08	1
Fort Bragg	39 24	123 48	1
Fresno	36 43	119 49	2
Glennville	35 45	118 42	1
Gold Run	39 12	120 50	1
Holcomb Valley	34 17	117 05	5
Hollister	36 50	121 20	1
Hot Springs	35 54	118 38	1
Indio	33 43	116 12	2
Julian	33 05	116 37	7
Lakeport	39 04	122 56	1
Lathrop	37 51	121 17	1
Lindsay	36 13	119 06	1
Livermore	37 40	121 45	1
Lonoak	36 20	122 00	4
Lone Pine	36 37	118 01	1
Los Angeles	34 03	118 15	3
McCloud	41 17	122 09	1
Magalia	39 45	121 36	1
Mammoth Tank	32 49	114 50	2
Markleeville	38 42	119 46	3
Mesa Grande	33 11	116 42	3
Mineral	40 21	121 32	2
Nellie	33 22	116 52	3
Nevada City	39 17	121 01	2
Newhall	34 22	118 30	2
Nordhoff	34 35	119 14	1
Northfork	37 08	119 33	1
Oak Grove	33 27	116 52	2
Oakland	37 47	122 15	4
Oroville	39 29	121 39	1
Ozena	34 53	119 16	1
Paso Robles	35 34	120 40	2
Peachland	38 23	122 38	2
Petaluma	38 15	122 38	3
Point Loma	32 43	117 15	5
Redding	40 36	122 24	2
Redlands	34 04	117 12	3
Rialto	34 12	117 27	1
Riverside	33 58	117 21	1
Rohnerville	40 33	124 11	2
Sacramento	38 35	121 30	1
Salinas	36 36	122 40	1
San Diego	32 43	117 10	3
San Francisco	37 48	122 26	6
San Jose	37 20	121 54	4
San Luis Obispo	35 18	120 39	3
San Pedro	33 45	118 14	1
Santa Barbara	34 23	119 40	1
Santa Monica	34 00	118 30	1
Seven Oaks	34 05	117 12	2
Shively	40 25	123 56	4
Soledad	36 28	121 16	1
Sonora	37 59	120 24	2
Spreckels	36 35	121 38	4
Stockton	37 57	121 22	1
Susanville	40 25	120 39	1
Tallac	38 56	120 03	1
Tamalpais	37 56	122 35	1
Towle	39 14	120 48	1
Tustin	33 46	117 46	2
Watsonville	36 55	121 46	3
Woodfords	38 47	119 49	1
Yorba Linda	33 51	117 50	1
COLORADO.			
Grand Junction	39 04	108 34	1
IDAHO.			
Aberdeen	42 56	112 52	2
Arrowrock	43 35	116 05	1
Boise	43 37	116 98	1
Bonners Ferry	48 42	116 30	1
Caldwell	43 42	116 42	1
Emmett	43 51	116 34	1
Fairfield	43 20	114 45	1
Garden Valley	44 08	115 58	1
Glenns Ferry	42 57	115 18	1
Hailey	43 32	114 20	1
Idaho City	43 34	115 58	1
Indian Valley	44 32	116 26	1

TABLE 1.—*Places in the United States reporting earthquakes during 1915*—Continued.

Place.	Approximate latitude.	Approximate longitude.	Number of quakes reported.
	° ′	° ′	
IDAHO—continued.			
Little Camas	42 52	114 42	1
Meridian	43 36	116 24	1
Mount Home	43 07	115 50	1
Montpelier	42 20	111 17	1
New Meadows	44 57	116 18	2
Payette	44 05	116 56	1
Pine	43 30	115 20	1
Pocatello	42 52	112 29	1
Shoshone	42 56	114 25	1
Silver City	43 02	116 46	1
Weiser	44 15	116 58	1
Wendell	42 48	114 42	1
ILLINOIS.			
Anna	37 27	89 18	1
Cairo	37 00	89 10	2
Equality	37 45	88 22	1
Golconda	37 24	88 31	1
Harrisburg	37 45	88 34	2
Olney	38 45	88 07	1
KENTUCKY.			
Benton	36 51	88 20	1
Calvert City	37 02	88 18	1
Clinton	37 40	89 00	1
Fulton	36 30	88 52	1
Hickman	36 35	89 12	1
Kevil	37 06	88 53	1
Lone Oak	37 03	88 42	1
Mayfield	36 45	88 38	2
Murray	36 37	88 17	1
Paducah	37 06	88 37	1
Wickliffe	36 58	89 06	1
MASSACHUSETTS.			
Andover	42 42	71 08	4
Haverhill	42 47	71 05	2
Lawrence	42 41	71 10	2
Lowell	42 39	71 20	2
MICHIGAN.			
Calumet	47 13	88 26	2
MISSISSIPPI.			
Tupelo	34 16	88 36	1
MISSOURI.			
Cardwell	36 04	90 16	1
Caruthersville	36 14	89 40	1
New Madrid	36 35	89 32	2
MONTANA.			
Lytle	48 01	111 26	1
Shelby	48 30	111 55	1
NEVADA.			
Arthur	40 32	115 21	1
Austin	39 31	117 05	2
Battle Mountain	40 40	116 57	1
Beowawe	40 36	116 29	1
Caliente	37 35	114 26	1
Carson City	39 11	119 48	1
Cherry Creek	39 53	114 51	1
Elko	40 51	115 45	2
Eureka	39 23	115 59	1
Fallon	39 30	118 48	7
Gerlach	38 55	119 43	4
Gold Creek	41 42	115 43	1
Golconda	40 58	117 30	2
Halleck	40 54	115 28	1
Lida	37 21	117 24	1
Las Vegas	36 09	115 09	1
Lovelock	40 11	118 30	1
McGill	39 19	114 48	1
Millett	39 01	117 15	1
Mina	38 24	118 06	1
North Fork	41 24	115 50	1
Paradise Valley	41 32	117 34	1
Rebel Creek	41 39	117 45	1
Reno	39 32	119 49	4
Sand Pass	40 15	119 48	3
San Jacinto	41 53	114 42	1
Sharp	38 07	115 28	1
Smith	38 43	119 21	1
Tecoma	41 14	114 05	1
Thorne	38 35	118 33	1
Tonopah	38 04	117 14	1
Unionville	40 28	118 09	1
Virginia City	39 14	119 40	1
Vya	41 34	119 53	1
Winnemucca	40 58	117 43	4
Yerington	38 58	119 11	5
NEW YORK.			
Beekmanton	44 45	73 24	1
NORTH CAROLINA.			
Asheville	35 36	82 32	1
NORTH DAKOTA.			
Williston	48 09	103 35	1
OREGON.			
Baker	44 46	117 50	1
Beckley	42 40	119 05	1
Burns	43 35	119 04	1
Fruita	45 20	116 50	1
Lakeview	42 12	120 20	1
Sunrise Valley	43 08	118 09	1
Valley Falls	42 32	120 15	1
SOUTH CAROLINA.			
Charleston	32 47	79 56	1
Summerville	33 05	80 14	1
TENNESSEE.			
Bristol	36 36	82 12	1
Brownsville	35 35	89 15	1
Memphis	35 09	90 03	1
Milan	35 55	88 46	1
Murfreesboro	35 52	85 27	1
Springville	36 17	88 11	1
Tiptonville	36 23	89 30	1
Union City	36 27	89 05	1
UTAH.			
Clarkston	41 55	112 04	1
Corinne	41 34	112 07	1
Emery	38 54	111 17	1
Enterprise	37 35	113 50	1
Garland	41 45	112 11	2
Grantsville	40 37	112 27	1
Grouse Creek	41 43	113 55	1
Heber	40 35	111 28	1
Ibapah	40 04	114 00	1
Iosepa	40 32	112 44	1
Kelton	41 35	113 06	1
Lehi	40 23	111 52	1
Lucin	41 22	113 54	1
Midvale	40 36	111 53	2
Modena	37 48	113 54	1
New Castle	37 50	113 30	1
Ogden	41 14	111 58	1
Park City	40 38	111 35	1
Promontory Point	41 13	112 27	1
Provo	40 16	111 44	1
Reed	38 35	113 10	1
Salt Lake City	40 46	111 54	4
Snowville	41 58	112 43	1
Spanish Fork	40 08	111 44	1
Standrod	42 00	113 26	1
Thistle	40 00	111 36	2
WASHINGTON.			
Ashford	46 48	121 56	1
Glacier	48 54	121 57	1
La Center	45 52	122 40	1
Lakeside	47 50	120 01	6
Laurier	48 59	118 13	1
Marblemount	48 32	121 36	2
Queets River	47 30	124 15	1
Seattle	47 38	122 20	1
Spokane	47 40	117 25	1
Sumner	47 12	122 13	1
Tacoma	47 16	122 23	1
Winthrop	48 28	120 10	1
WYOMING.			
Bedford	42 56	110 56	1
Yellowstone National Park	44 20	110 20	2
PORTO RICO.			
Arecibo	18 28	66 44	4
Isaoela	18 30	67 04	1
Lares	18 23	66 55	2
Mayaguez	18 13	67 09	1
San Juan	18 29	66 07	1
Vieques	18 09	65 27	1

SECTION VI.—BIBLIOGRAPHY.

RECENT ADDITIONS TO THE WEATHER BUREAU LIBRARY.

C. FITZHUGH TALMAN, Professor in Charge of Library.

The following have been selected from among the titles of books recently received as representing those most likely to be useful to Weather Bureau officials in their meteorological work and studies.

Abbe, Cleveland.
Biographical memoir of Charles Anthony Schott, 1826–1901. Washington. 1915. 1 p. l., 87–133 p. front. 23½ cm. (National academy of sciences. Biographical memoirs, part of v. 8.) [With portrait.]

Académie des sciences, *Paris.*
Procès-verbaux des séances de l'Académie, tenues depuis la fondation de l'Institut jusqu'au mois d'août 1835. T. 1–4 (1795–1811). Hendaye. 1910–1914. 4v. 32½ cm.

Bengelsdorff, G.
Wie man für einen gewissen Ort im Voraus den wahrscheinlichen Gang der Temperaturvariationen während einer beliebigen zukünftigen Zeitperiode bestimmen kann. Helsingfors. [1915.] 1 p. l., 55–81 p. 2 pl. (Vergleichende Studien II, zweiter Abschnitt.)

Bremen. [Meteorologisches Observatorium.]
Deutsches meteorologisches Jahrbuch für 1913. Freie Hansestadt Bremen. Jahrgang 24. Bremen. 1914. iv, 88 p. 32 cm.

Canada. Meteorological service.
Report for the year ended December 31, 1912. Ottawa. 1915. 2 v. 29 cm.

Day, P[reston] C.
What the Weather Bureau is doing in agricultural meteorology. Rome. 1915. 4 p. 23 cm. (*Reprinted from* International institute of agriculture. Bureau of agricultural intelligence and and plant diseases. Monthly bulletin, May, 1915.)

Dudley, P. H.]
Forecast and chart of mild and cold winters. [New York. 1915.] 4 p. chart. 26½ cm. ([Published by the] New York Central Lines.)

Fontseré, Eduardo.
Desarrollo de la brisa marina en el litoral de Barcelona. Barcelona. 1915. 4 p. v charts. 30 cm. (Memorias de la Real academia de ciencias y artes, tercera época, v. 11, núm. 26.)
La estación sísmica del Observatorio Fabra y su funcionamiento durante el año 1914. Barcelona. 1915. 13 p. 30 cm. (Memorias de la Real academia de ciencias y artes, tercera época, v. 12, núm. 6.)

Hodgson, W. Earl.
How to fish. A treatise on trout & trout-fishes. London. 1907. xii, 377 p. 20½ cm. [Chapter 9, Influences of the weather.]

Hunsaker, J. C., *and others.*
Reports on wind tunnel experiments in aerodynamics. Washingington. 1916. iii, 92 p. 5 pl. 24½ cm. (Smithsonian miscellaneous collections, v. 62, no. 4.)

Korea. Meteorological observatory.
Annual report for the year 1914. Chemulpo. 1915. v. p. 30½ cm.

Mascart, Jean.
La météorologie et l'aviation. Torino. 1915. 26 p. 24½ cm. (Estratto da Saggi di astronomia popolare, anno 5, 1915.) [In French.]

Montessus de Ballore, F. de.
El terremoto del 16 de Agosto de 1906. Santiago-Valparaiso. 1915. 407 p. 25½ cm. (Historia sísmica de los Andes Meridionales, quinta parte.)

Philippine Islands. Weather bureau.
Annual report for the year 1913. Part III: Meteorological observations made at the secondary stations. Manila. 1915. 331 p. 29½ cm.

Prussia. K. Meteorologisches Institut.
Aspirations-Psychrometer-Tafeln. 2. erweiterte Auflage. Braunschweig. 1914. xiv, 123 p. 32 cm.

Peters, O. S.
Protection of life and property against lightning. Washington. 1915. 127 p. plates. 25½ cm. (U. S. Bureau of standards. Technologic papers, no. 56.)

Quayle, E. T.
Relation between cirrus directions as observed in Melbourne and the approach of the various storm systems affecting Victoria. Melbourne. 1915. 27 p. plate. 30½ cm. (Australia. Commonwealth bureau of meteorology. Bulletin no. 10.)

Sievert, Otto.
Wandtafel zur Wetterveranschaulichung. Tafel 1: Wind und Wetter. Berlin. [1914.] chart, 91 x 77 cm.
Wandtafel zur Wetterveranschaulichung. Tafel 2: Zugstrassen und Wettertypen. Berlin. [1914.] chart, 92 x 77½ cm.

Tippenhauer, L. G.
Die elektromagnetische Theorie des Wetters. 2. Teil: Das Klima Westindiens während der Sonnenpfleckperiode 1901–1912. Port-au-Prince. 1916. 66 p. plate. 30 cm.

Venice. Ufficio idrografico.
Gli osservatori meteorologici della rete di 1° ordine. Venezia 1915. 24 p. plates. 26 cm.

Very, Frank W.
The photographic spectrography of the earth-shine, and a spectrophotometric comparison of the earth-shine with moonlight, skylight, and sunlight, together with a study of the difficulties of photographic comparisons. Kiel. 1915. p. 354–399. 29 cm. (Abdruck aus den Astr. Nachr., Nr. 4819–20, Band 201; Nov. 1915.)

RECENT PAPERS BEARING ON METEOROLOGY AND SEISMOLOGY.

C. FITZHUGH TALMAN, Professor in Charge of Library.

The subjoined titles have been selected from the contents of the periodicals and serials recently received in the Library of the Weather Bureau. The titles selected are of papers and other communications bearing on meteorology and cognate branches of science. This is not a complete index of the meteorological contents of all the journals from which it has been compiled. It shows only the articles that appear to the compiler likely to be of particular interest in connection with the work of the Weather Bureau.

Aeronautical journal. London. v. 19. July–September, 1915.
Hankin, E. H. On the flight of sea gulls. p. 84–103. [Discusses atmospheric conditions of soaring flight.]

American society of civil engineers. Proceedings. New York. v. 41. December, 1915.
American society of civil engineers. Progress report of the special committee on floods and flood prevention. p. 2771–2787.

Astrophysical journal. Chicago. v. 42. December, 1915.
Fowle, F[rederick] E[ugene]. Transparency of aqueous vapor. p. 394–411.

Electrical world. New York. v. 66. December 18, 1915.
Holmgren, Torsten. Protecting tower lines from sleet; nature of damage resulting from sleet storms—recommendations for designing transmission lines in Sweden. p. 1372.

Engineering news. New York. v. 74. December 23, 1915.
Boardman, H. P. Severe earthquake in Nevada. p. 1222–1223.

Franklin institute. Journal. Philadelphia. v. 181. January, 1916.
King, Louis Vessot. The linear hot-wire anemometer and its applications in technical physics. p. 1–25.

Geographical journal. London. v. 46. November, 1915.
Davison, Charles. Earthquakes in Great Britain. (1889–1914.) p. 357–374.

Meteorological society of Japan. Journal. Tokyo. 34th year. January, 1916.
Okada, T. Some researches in the far eastern seasonal correlations. (First note.) p. 19–36. [This REVIEW, Jan. 1916.]

Nature. London. v. 96. 1915.
Monuments and lightning. p. 286. (Nov. 11.) [Abstract of memoir by Galli.]
Atmospheric pollution. p. 442–444. (Dec. 16.)

Physical review. Lancaster. v. 7. January, 1916.
Wright, J. R., & Smith, C. F. The free ions in the atmosphere of the tropics. p. 49–61.
Allen, S. J. M. The radioactive deposit from the atmosphere on an uncharged wire. p. 133–138.

Royal society. Proceedings. London. ser. A. v. 92. no. A 637. January 1, 1916.
Joly, J. On a method of estimating distances at sea in fog or thick weather. p. 170–175. [Discusses use of simultaneous radiotelegraphic, submarine, and aerial signals.]
Taylor, G. I. Skin friction of the wind on the earth's surface. p. 196–199.

School science and mathematics. Chicago. v. 16. January, 1916.
Barber, Fred. B. Indoor humidity. p. 52–56.

Scientific American. New York. v. 113. September 25, 1915.
Earthquake dangers in the United States. p. 266.

Scientific American. New York. v. 114. January 8, 1916.
Prevention of fog by a blanket of oil. p. 61.
Scientific American supplement. New York. v. 81. January 15, 1916.
Radio-active substances in the air and atmospheric fog.
Scientific monthly. New York. v. 1. December, 1915.
McAdie, Alexander. Theory and practice of frost fighting. p. 292–301.
Scientific monthly. New York. v. 2. February, 1916.
McAdie, Alexander. Battles and rainfall. p. 170–173.
Seismological society of America. Bulletin. Stanford university. v. 5. December, 1915.
Jones, Claude J. The Pleasant Valley, Nevada, earthquake of October 2, 1915. p. 190–205.
Klotz, Otto. Earthquake of February 18, 1911. p. 206–213. [Translation, with notes, of article by Galitzin.]
Wood, Harry O. On a possible causal mechanism for heave-fault slipping in the California coast range region. p. 214–229.
Davis, E. F. The earthquakes of October 7, 1915, in central California. p. 230–235.
Symons's meteorological magazine. London. v. 50. December, 1915.
Richard Manliffe Barrington. 1849–1915. p. 169–170. [Obituary.]
Bonacina, L. C. W. Professor Pettersson on lunar periods in solar and terrestrial climate. p. 171–176.
Terrestrial magnetism and atmospheric electricity. Baltimore. v. 20. December, 1915.
Störmer, Carl. Preliminary report on the results of the aurora-borealis expedition to Bossekop in the spring of 1913. (Third communication.) p. 159–174.
Morize, H[enrique]. Sur le champ électrique de l'atmosphère à Rio de Janeiro. p. 175–186.
Académie des sciences. Comptes rendus. Paris. tome 161. 1915.
Chudeau, R[éné]. La pression atmosphérique en Afrique occidentale et équatoriale. p. 351–354. (20 sept.)
Mascart, Jean. Description d'un orage localisé. p. 354–355. (20 sept.)
Chudeau, R[éné]. La pluie et la tension de vapeur en Afrique occidentale et équatoriale. p. 392–395. (27 Sept.)
Annales de géographie. Paris. 23–24 année. 15 novembre 1915.
Chudeau, R[éné]. Trois perturbations barométriques au nord de Tombouctou. p. 443–449.
Astronomie. Paris. 29 année. Novembre, 1915.
Guillaume, Ch[arles] Ed. Le son du canon. p. 390–394.
Revue générale des sciences. Paris. 25 année. 15 février 1914.
Organisation et fonctionnement du service météorologique des États-Unis. p. 113–118.
Annalen der Hydrographie und maritimen Meteorologie. Berlin. 43. Jahrgang. 1915.
Thraen, A[ugust]. Der Einfluss der Nord- und Ostsee auf den Niederschlag in der norddeutschen Tiefebene. p. 497–513; 549–581. (H. 11, 12.)
Retzow, Ulrich. Die interdiurne Veränderlichkeit der Lufttemperatur in Europa. p. 513–520. (H. 11.)
Beiträge zur Geophysik. Leipzig. 14. Band. 2. Heft. 1915.
Conrad, V[ictor]. Einige Bemerkungen zur Aufzeichnung des Bebens vom 13. Januar 1915. k. M. p. 21–24.
Gutenberg, B. A. de Quervain, Die Ausbreitung des Kanonendonners aus dem Sundgau. k. M. p. 34. [Abstract from Umschau.]
Deutsche Luft-fahrer Zeitschrift. Berlin. 19. Jahrgang. 22. Dezember 1915.
Krebs, Wilhelm. Genaue Feststellung von Druckverschiebungen in der Atmosphäre. p. 219–221.
Geographische Zeitschrift. Leipzig. 21. Jahrgang. 10. Heft. 1915.
Gradmann, R[obert]. Das Problem der Klimaänderung in geschichtlicher Zeit. p. 586–591. [Abstract of work by L. Berg.]
Meteorologische Zeitschrift. Braunschweig. Band 32. November. 1915.
Knoche, Walter. Auffallende stille Entladungen während eines Gewitters in Valparaiso. p. 481–484.
König, Walter. Zyklonen und Kreiseltheorie. p. 484–488.
Hann, J[ulius] v. Temperaturverhältnisse von Quito. p. 488–500. [Extr. Sitzb. k. Akad., Wien.]
Thomas, Oswald, Ueber die Nebelverhältnisse von Wien. p. 501–505.
Huber, P. Bonifacius. Luftelektrische Beobachtungen und Messungen bei Föhn. p. 512–513.
Tschaplowitz, F. Ueber Feuchtigkeitsmessung der Luft. p. 513–515.
Maurer, J[ulius]. Die Beziehung gesteigerter Sonnentätigkeit zu atmostphärisch-optischen Erscheinungen. p. 515–517. [See this REVIEW, November, 1915, p. 545.]
Gruner, P[aul]. Ueber die Photometrie des Purpurlichtes. p. 518–519.
Schlikker, B. Die Maurersche Schwankungssumme *S*. p. 519–520.
Meissner, Otto. Sind die Berliner Winter wärmer geworden? p. 521–522.

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Naturwissenschaften. Berlin. 3. Jahrgang. 5. November 1915.
Freundlich, Erwin. Ueber die Bestimmung der Solarkonstante un den dabei zutage getretenen Lichtwechsel der Sonne. p. 606–609.
Petermanns Mitteilungen. Gotha. 61. Jahrgang. August-Heft. 1915.
Tauern, Odo. Die Molukkeninsel Misol. p. 311–314.
Physikalische Zeitschrift. Leipzig. 16. Jahrgang. 1915.
Gutenberg, B. Ueber mikroseismische Bodenunruhe. p. 285–287. (1. Aug.)
Gockel, A[lbert]. Beiträge zur Kenntnis der in der Atmosphäre vorhandenen durchdringenden Strahlung. p. 345–352. (1. Okt.)
Prometheus. Leipzig. Jahrgang 26. 1915.
Damm, O. Das Erfrieren der Pflanzen. p. 537–538. (22 Mai.)
Ehlert, F. Geschützdonner ohne Geschütze und ähnliche Erscheinungen. p. 556–557. (29 Mai.)
Wetter. Berlin. 32. Jahrgang. 1915.
Maurer, J[ulius]. Der meteorologische Landesdienst der Schweiz und deren Wasserwirtschaft. p. 1–10. (Jan.)
Fischer, Karl. Temperaturgang und Oderhochwasser. p. 10–15; 25–31. (Jan., Feb.)
Naegler, W[ilhelm]. Ueber künstliche Beeinflussung des Klimas. p. 21–22. (Jan.)
Dreis, J[ohannes]. Die Kälteperioden des nordischen Winters. p. 35–40. (Feb.)
Die Seltenheit der Nordlichterscheinungen in Süddeutschland und der Schweiz seit 1875. p. 40–41. (Feb.)
Strenge und milde Winter. p. 43–44. (Feb.)
Schreiber, Paul. Die klimatischen Verhältnisse von Dresden und einigen anderen Orten Sachsens. p. 49–59; 73–85. (März, Apr.)
Ueber Blitzschäden auf der meteorologischen Station am Säntisgipfel. p. 64–65. (März.)
Freybe, O[tto]. Das Verstärken von Tiefdruckwirbeln. p. 70–72. (März.)
Naegler, W[ilhelm]. Die Oberflächentemperatur im Sand und Moor in Neu-Hammerstein in Pommern. p. 90–93. (Apr.)
Rudel, [Kaspar]. "Frontgewitter." p. 93–94. (Apr.)
Rudel, [Kaspar]. Vom Verlauf der Sonnenfinsternis und deren Begleiterscheinungen zu Nürnberg am 21. August 1914. p. 94–95. (Apr.)
K., W. Der 70. Geburtstag des Herausgebers des "Wetter." p. 96. (Apr.)
Kassner, Carl. Ueber die Zunahme des Nebels in Sofia und ihre Ursachen. p. 97–102. (Mai.)
Fischer, [Karl]. Das Klima von Trier an der Mosel. p. 102–112. (Mai.)
Dreis, J[ohannes]. Die Wärmeperioden des nordischen Sommers. p. 115–119. (Mair.)
Rudel, [Kaspar]. Wirkungsweise von Böen. p. 119–120. (Mai.)
Gockel, A[lbert]. Zur Gewittervorhersage. p. 121–124. (Juni.)
Marvin, Charles Fred[erick]. Erklärung der Luft-Drainage. p. 124–131. (Juni.) [Translated by D. Burchard from MONTHLY WEATHER REVIEW, October, 1914, p. 583–585.]
Richter, P. Verdeutschungen in der Wetterkunde. p. 137–140. (Juni.)
Meissner, Otto. Bemerkenswerte Witterungsereignisse der letzten Jahre (1908–1914). p. 141–144; 235–240; 258–264. (Juni, Okt., Nov.)
Fischer, Rudolf. Der Einfluss des Mondes auf die Wetterumschläge und die atmosphärischen Störungen. p. 161–165. (Juli.)
Hornberger, R. Zur Kenntnis des Klimas von Münden. p. 145–154; 169–175. (Juli, Aug.)
Thraen, August. Die örtlichen Unterschiede im durchschnittlichen jährlichen Niederschlag für Deutschland und ihre Erklärung. p. 175–183; 193–201. (Aug., Sept.)
Dietzius, Robert. Wiener Pilotballonaufstiege. p. 202–205; 226–229. (Sept., Okt.)
Weichbrodt, Heinz. Luftspiegelung. p. 210–213. (Sept.)
Hennig, R[ichard]. Die problematische Beeinflussung des Wetters durch den Krieg. p. 217–221. (Okt.)
Willner, Rudolf. Die Höhlentemperatur. p. 241–248. (Nov.)
Moliy. Ueber Luftspiegelung. p. 248–251. (Nov.)
Rudel, K[aspar]. Pflanzenphänologie und Klimakunde. p. 255–257. (Nov.)
Hemel en Dampkring. Den Haag. 13 Jaarg. 1915.
Everdingen, E. van. Dagelijksche enn jaarlijksche gang in de halo-verschijnselen. p. 85–90. (Oct.)
Cannegieter, H. G. Vliegmachines in dienst der meteorologie. p. 105–107. (Nov.)
Stok, J. P. van der. Het klimaat van Nederlandsch-Indië. p. 108–110. (Nov.)
Società degli spettroscopisti italiani. Memorie. Catania. v. 4. Marzo 1915.
Zedda, Cesare. Sopra un fenomeno ottico dell' atmosfera. p. 35–38.

SECTION VII.—WEATHER AND DATA FOR THE MONTH.

THE WEATHER OF THE MONTH.

P. C. DAY, Climatologist and Chief of Division.

[Dated: Weather Bureau, Washington, Feb. 3, 1916.]

PRESSURE.

The distribution of the mean atmospheric pressure over the United States and Canada and the prevailing direction of the winds are graphically shown on Chart VII, while the average values for the month at the several stations, with the departures from the normal, are shown in Tables I and III.

For the month as a whole the mean barometric pressure was below the normal over most of the country. The only sections showing positive departures were the upper Lake region, the interior of the northern portion of the Pacific States, and the central Florida Peninsula. The positive departures were generally small, the greatest values appearing in the northern portion of the upper Lake region. On the other hand, the negative departures were quite marked in New England and the Canadian Provinces to the eastward.

The month opened with relatively high pressure throughout most sections, except in the upper Lake region and along the Pacific coast, where it was near or slightly below the normal. High pressure continued for about a week over most sections, except along the northern and southern borders, where it was relatively low most of the time. From the latter part of the first week until near the end of the fourth week a succession of rather extensive and well-defined low and high pressure areas followed each other across the country, with rather sluggish movement at times.

During the latter part of the month rather marked low pressure prevailed throughout most southern sections, while in the northern districts pressure was generally high. However, the month closed with relatively low pressure in the extreme southwest, northwest, and northeast sections of the country, while elsewhere high pressure obtained.

The distribution of the highs and lows was generally favorable for northwesterly and westerly winds in the New England and Middle Atlantic States, the Lake region, the upper Mississippi and the Missouri Valleys, southerly and southeasterly in the Central and West Gulf States and the lower Mississippi Valley. Elsewhere variable winds prevailed.

TEMPERATURE.

The month opened with cool weather prevailing in the Eastern and Southern States and with a decided fall in temperature in the Rocky Mountain districts, but relatively warm weather obtained in the West Gulf region and the great central valleys. During the following day or two there was a slight warming up in the more eastern districts, but at the same time cooler weather obtained in the great central valleys, which by the middle of the first decade had overspread all districts to the eastward of the Mississippi River, and in the meantime temperatures had risen materially in Plateau and Rocky Mountain districts. There were no important or widespread temperature changes during the last half of the first decade, but by the beginning of the second considerably warmer weather had set in over the Southwest, which advanced during the next few days into the East Gulf and South Atlantic districts. At the same time a high-pressure area, with much colder weather, advanced into the northern Plains region and temperature readings of −10°F. were reported from points in those districts. This cold area moved rapidly eastward, but with decreasing intensity, and by the middle of the month considerably warmer weather was again in evidence over the Plains States and the central valleys to the eastward. During the last half of the second decade temperature changes were frequent in most districts east of the Rocky Mountains, warm and cold spells succeeding each other rather rapidly, but there were no pronounced or widespread abnormal temperature conditions, while to the westward of the mountains cold weather predominated.

At the beginning of the third decade temperatures had fallen considerably in the southern Rocky Mountain districts and West Gulf States, but at the same time a warm area was advancing from the Northwest. It moved southeastward during the following few days, and by the 23d there was a general warming up in most eastern districts. Near the middle of the decade decidedly cooler weather had again advanced into the Plains region and West Gulf States and by the 26th considerably lower temperatures obtained in most districts to the eastward of the Mississippi. During the last few days of the month temperature changes were rather frequent but not unusually large, and the areas affected were comparatively small. The month closed, with abnormally low temperatures in New England and the interior of New York, and likewise over the Northwest and generally west of the Rocky Mountains, −16° being reported from Northfield, Vt., and −24° at Lander, Wyo., on the morning of the 31st.

Day temperatures.—Much cloudy weather over eastern districts resulted in only moderately high day temperatures despite the general absence of any severe cold. At a few points they were as high as any previously recorded in December, especially in the far Northwest on the 8th, over the middle Plains region on the 22d, and along the Virginia coast on the 29th. Over the northern districts from the Dakotas eastward the maximum temperatures did not rise much above 40°, and at some places they were below that point.

Night temperatures.—Over all districts from the Rocky Mountains eastward the night temperatures were moderately high; in fact, at no points did the extremes closely approach the low readings of some previous years. Similar conditions prevailed in the far West also until near the end of the month, when a cold area overspread the northern portions, and minimum temperatures on the mornings of the 30th and 31st were as low as, or lower than, any previous December record in some districts.

Monthly averages.—Over nearly all districts from the Mississippi River eastward the monthly means were near or slightly below normal, while to the westward they were above normal, save for a small area in the Plateau region. The excesses were generally small, however, except in the Missouri Valley and the eastern portions of the Plains region, where they ranged from +3 to +6 degrees.

PRECIPITATION.

High pressure dominated weather conditions in most districts during the first few days of the month and consequently only local precipitation occurred, although there was heavy snowfall along the eastern end of Lake Ontario on the 3d and 4th, and considerable precipitation occurred in the far western districts, beginning about the 2d.

On the 6th and 7th low pressure obtained in the west Gulf region, attended by heavy rainfall in portions of Texas, while at the same time a storm of considerable severity moved along the northern border, but it was attended by comparatively light precipitation.

The first general and important storm of the month moved from the eastern slope of the Rocky Mountains on the 9th to the New England coast by the 14th, accompanied by general precipitation in nearly all districts from the middle Plains region to the Atlantic coast and New England, with heavy snows in portions of the Appalachian Mountains and North Atlantic States. This storm reached New England with greatly increased intensity, attended by shifting gales on the coast and high winds, snow, and sleet in the interior of the northeastern States, the snowfall being unusually heavy from central Pennsylvania northeastward to New England, nearly 3 feet occurring at points in New York.

Closely following the above-mentioned storm, another low-pressure area appeared in the far Southwest about the 15th, and during the last half of the second decade storm movement was rapid over eastern districts, with general precipitation and heavy local rainfalls in the Gulf States.

From the 19th to the 23d high pressure prevailed over most districts with resultant generally fair weather, except that local heavy rain or snow occurred in portions of the Southeastern States about the 20th, the snowfall being unusually heavy in the eastern portion of the Carolinas, the fall at Wilmington, N. C., from 8 p. m. of the 20th to 8 a. m. of the 21st being about 7 inches, the heaviest of record for December. However, about the 23d a depression developed in the central Rocky Mountain region, moving southeastward to Oklahoma by the following day, and thence northeastward to New England by the 26th, with greatly increased intensity. This storm was attended by rains and snows over most sections from the Plains region eastward, and by heavy snows locally from Missouri northeastward to lower Michigan, and by high winds along the Atlantic coast. Closely following this storm another low pressure area appeared in the Southwest about the 27th, advancing eastward to the west Gulf by the following day. Thence it moved rapidly northeastward to New England, attended by general, and in some cases heavy rains in the southern districts, and by rain, sleet, or snow from the Ohio Valley and Lake region eastward. At the same time rains occurred in the Pacific Coast States and quite general snows in the Rocky Mountain and Plateau districts, the snowfall being unusually heavy at elevated points in northern Arizona.

The month closed with an extensive area of high pressure overlying the country to the eastward of the Rocky Mountains, and with generally fair weather prevailing in eastern districts, but low pressure obtained in the far Southwest, which was causing rains and snows in the southern portions of the Plateau and Rocky Mountain regions, and local rains in the southern Plains States and west Gulf districts.

Snowfall.—Some heavy falls of snow occurred in portions of New York, Pennsylvania, and the New England States, but elsewhere east of the Rocky Mountains the amounts as a rule were light. In the far western mountains moderate to heavy falls appear to have occurred in portions of Washington, Oregon, California, and Arizona, while elsewhere on the western slope of the Rockies the amounts were generally moderate to light.

GENERAL SUMMARY.

While severe storms prevailed over the northeastern districts about the 13th and 26th, other portions of the country were remarkably free from the adverse conditions that frequently prevail during December, and on the whole the weather was favorable for the usual growth of winter crops and the pursuit of such outdoor work as is commonly performed during a winter month.

In the corn and winter wheat-growing regions favorable weather permitted the gathering of the greater part of the corn crop, although in Kansas much still remained ungathered. Winter wheat was very generally reported in good condition, and some protection was afforded by a slight snow cover at the period of coldest weather. The surface soil was becoming very dry in portions of Oklahoma, and wheat was suffering to some extent, but in most other districts the soil contained sufficient moisture for the present needs of that crop.

In the southern districts the weather was mostly favorable, little damage occurred from cold in the winter trucking sections, and fall-sown oats and other grains were in good condition.

On the great stock ranges of the West the absence of any material snow cover for lengthy periods permitted of continued winter grazing, save in some northern districts where on account of late growth the grass was not matured when freezing weather occurred, and in the far Northwest where drought in the fall and considerable snow cover later rendered much feeding necessary. As a rule, stock of almost every kind was reported in good condition not only on the ranges but on the farms of the central and eastern districts.

Over the North Atlantic States severe storms with high winds caused serious damage along the coast, while inland heavy snows and high winds interfered greatly with transportation and overhead wire communication. Sleet storms in the Ohio Valley caused delay in transportation and damage to overhead wires and trees, and heavy rains in portions of the southern Appalachian Mountain region caused local freshets.

Average accumulated departures for December, 1915.

Districts.	Temperature.			Precipitation.			Cloudiness.		Relative humidity.	
	General mean for the current month.	Departure for the current month.	Accumulated departure since Jan. 1.	General mean for the current month.	Departure for the current month.	Accumulated departure since Jan. 1.	General mean for the current month.	Departure from the normal.	General mean for the current month.	Departure from the normal.
	°F.	°F.	°F.	Ins.	Ins.	Ins.	P. ct.		P. ct.	
New England	30.5	+1.2	+15.4	4.05	+0.70	−4.90	6.6	+0.5	76	0
Middle Atlantic	34.0	−1.2	+10.0	3.64	+0.50	−2.50	6.3	+0.5	72	−3
South Atlantic	45.2	−1.9	+ 5.5	2.66	−1.00	−8.30	4.2	−0.7	73	−5
Florida Peninsula	64.1	−1.7	− 5.3	2.18	+0.20	−3.80	4.3	−0.4	77	−5
East Gulf	49.6	+0.4	+ 7.9	5.54	+1.00	+0.40	5.5	0.0	77	0
West Gulf	51.9	+2.8	+ 4.3	3.04	+0.20	−4.30	5.3	+0.1	73	−1
Ohio Valley and Tennessee	35.6	−1.2	− 0.2	5.78	+2.40	+0.20	7.5	+1.2	78	+2
Lower Lakes	28.1	−1.0	+ 0.5	2.97	+0.10	−1.30	8.4	+0.7	81	+3
Upper Lakes	24.8	+0.3	+10.0	1.34	−0.80	−2.90	7.8	+0.5	84	+2
North Dakota	16.9	+5.0	+23.1	0.62	0.00	−0.50	6.4	+1.0	85	+6
Upper Mississippi Valley	28.0	+0.6	+ 6.3	1.72	−0.10	+6.20	6.7	+0.9	81	+3
Missouri Valley	30.3	+3.4	+ 6.5	1.05	0.00	+7.70	5.7	+0.5	77	+2
Northern slope	25.8	+2.1	+ 7.7	0.94	+0.10	+2.50	6.0	+0.8	72	+4
Middle slope	35.8	+2.8	− 1.0	0.39	−0.40	+7.10	4.5	+0.4	68	+2
Southern slope	46.4	+2.6	− 4.1	0.51	−0.40	+0.60	3.9	−1.1	59	−7
Southern Plateau	44.1	−0.8	−16.1	0.86	+0.30	+0.90	3.4	+0.2	54	+8
Middle Plateau	31.9	+0.7	+ 0.8	1.11	+0.10	−1.50	5.9	+1.1	70	0
Northern Plateau	32.2	+0.2	+16.3	1.58	−0.20	−0.20	8.0	+1.2	75	−5
North Pacific	42.2	+0.6	+22.2	10.21	+2.30	−4.10	8.3	+0.5	85	−1
Middle Pacific	48.3	−0.2	+ 7.3	5.35	+0.90	+2.40	5.8	+0.4	77	−3
South Pacific	53.6	+0.6	+14.3	2.87	+0.70	+3.20	4.2	−0.1	69	0

LOCAL STORMS DURING DECEMBER.

The following notes of severe storms have been extracted from the report of the section director, Vicksburg, Miss.:

On December 17, 1915, a series of severe local storms or tornadoes passed over parts of Clark, Lauderdale, and Kemper Counties. The storms appeared at all points between 4 and 5 a. m. and were accompanied by inky black clouds of the usual pendant formation, frequent electrical discharges, very high wind velocities, and heavy rains followed. The paths of the storms ranged from 50 to 800 yards in width. There were 6 deaths, about 75 persons were injured, and property loss estimated at $200,000. Every building in the vicinity of Preston, Kemper County, was demolished.

THE TORNADO OF DECEMBER 17, 1915, IN EASTERN MISSISSIPPI.

By DON MCNEAL, Assistant Observer.

[Dated: Weather Bureau, Meridian, Miss., Jan. 7, 1916.]

In concurrence with the passing of a cyclonic area over Mississippi during the night of December 16 and the early morning of the 17th a severe local storm was experienced over Clark, Lauderdale, and Kemper Counties in eastern Mississippi. The depression, appearing over northeastern Mississippi and central Tennessee, as based on the 8 a. m. reports of December 17, appeared to be a secondary center of the storm then moving eastward over the Great Lakes, and served to outline a well-defined and characteristic V-shaped depression over the southern States.

Thunder was heard at the Meridian station during the early morning, but no unusual phenomena were observed. The storm first appeared in violence as a tornado near Shubuta, in the southern portion of Clark County. From here it moved north and northeastward in a zigzag and erratic manner, and with decreasing violence as it approached the more uneven topography of Lauderdale County. It appeared to have spent itself at this point, but later reappeared with extreme violence near Daleville, in the northern portion of the county. It then continued in intensity, and again moved northeastward in a broken and uneven course across the swampy and heavily forested areas of that section, leaving destruction in its wake throughout a path ranging in width from 50 to 800 yards. It was last observed in the vicinity of Geiger, Ala., which place marks the end of the path of serious damage.

This tornado appeared between 4 and 5 a. m. at all places throughout its course, so that observations of the meteorological elements were incomplete and lacking in detail. All observers agree, however, that the clouds were inky black; that there were frequent electrical discharges which, in some instances, were observed as converging to a common center; that the disturbance passed at an extreme velocity, and that the usual pendant-formed cloud was present. No hail was reported from any point along the path of the storm, but in every case heavy rains followed immediately as the high winds subsided.

Throughout its path, buildings were unroofed or completely demolished, and heavy timber was uprooted and strewn about in a heterogeneous manner with other débris. At Preston, practically the entire town was destroyed, and many persons were injured, although no deaths are reported. Five miles east of Scooba, where the storm seems to have developed its greatest violence, many peculiar incidents are related in connection with it. Here limbs are said to have been torn from one side of pine trees, while on the other side the limbs and branches were left intact; one side of the roof of a barn was torn completely off, while the other side remained undamaged; one oak tree 4 feet in diameter was uprooted and carried 16 feet and then left resting with the top pointing toward the southwest. Another oak tree 30 inches in diameter was severely twisted at a point 4 feet above the ground and left standing in this condition. One instance is related where it is said that a negro woman was picked from her bed and dashed to death, while a 4-month-old child lying by her side remained unhurt. In another house, where all windows and doors were blown out, a quart of canned fruit, in a glass container, was lifted from the mantelpiece and deposited on the floor undamaged. A negro child was said to have been carried a distance of 300 feet by the wind and lodged in a tree, where it was found, after the storm had passed, in a dying condition.

Authentic reports place the number of deaths resulting from this storm at 6—all negroes—while the number of persons injured will probably reach 75. Property loss, including damage to timber, is estimated at $200,000.

Maximum wind velocities, December, 1915.

Station.	Date.	Velocity.	Direction.	Station.	Date.	Velocity.	Direction.
		Mis./hr				*Mis./hr.*	
Block Island, R. I.	10	54	nw.	Norfolk, Va.	18	53	sw.
Do.	13	60	ne.	Do.	25	58	w.
Do.	14	60	w.	Do.	26	50	w.
Do.	18	56	nw.	Do.	29	53	sw.
Do.	26	86	w.	North Head, Wash.	2	52	se.
Do.	29	67	ne.	Do.	4	72	se.
Boston, Mass.	13	52	ne.	Do.	5	70	s.
Buffalo, N. Y.	19	52	w.	Do.	7	72	se.
Do.	23	54	w.	Do.	8	68	se.
Do.	24	50	w.	Do.	19	78	se.
Do.	25	54	w.	Do.	20	76	s.
Charlotte, N. C.	25	50	sw.	Do.	21	63	s.
Do.	29	58	sw.	Do.	24	54	s.
Chattanooga, Tenn	29	59	sw.	Do.	27	54	s.
Cheyenne, Wyo.	14	58	w.	Do.	28	70	nw.
Do.	20	70	w.	Pensacola, Fla.	28	70	sw.
Do.	21	66	w.	Point Reyes Light,			
Do.	22	72	w.	Cal.	3	66	s.
Do.	25	56	w.	Do.	9	52	nw.
Columbus, Ohio.	23	50	w.	Do.	12	65	s.
Eastport, Me.	14	63	ne.	Do.	13	67	s.
El Paso, Tex.	26	51	w.	Do.	14	52	nw.
Do.	31	54	sw.	Do.	25	66	nw.
Erie, Pa.	17	52	se.	Do.	28	68	nw.
Fort Worth, Tex.	24	50	nw.	Portland, Me.	26	54	nw.
Hartford, Conn.	26	58	nw.	Providence, R. I.	14	52	w.
Hatteras, N. C.	18	52	sw.	Do.	15	52	w.
Do.	25	52	sw.	Do.	18	50	w.
Do.	26	66	w.	Do.	26	82	nw.
Key West, Fla.	20	56	n.	Richmond, Va.	25	50	sw.
Lexington, Ky.	29	56	sw.	Sand Key, Fla.	11	50	se.
Mt. Tamalpais, Cal.	3	58	sw.	Do.	20	66	nw.
Do.	4	57	nw.	Sandy Hook, N. J.	9	52	nw.
Do.	8	50	nw.	Do.	10	55	nw.
Do.	9	62	nw.	Do.	13	61	nw.
Do.	13	54	sw.	Do.	14	55	w.
Do.	25	54	nw.	Do.	18	50	nw.
Do.	26	57	n.	Do.	26	76	w.
Do.	28	67	nw.	Do.	29	59	ne.
Do.	29	53	nw.	Savannah, Ga.	25	52	w.
Mobile, Ala.	28	50	sw.	Seattle, Wash.	19	57	sw.
Nantucket, Mass.	13	72	e.	Do.	21	52	sw.
Do.	14	72	sw.	Tatoosh Island,			
Do.	26	72	sw.	Wash.	4	52	s.
Do.	29	60	ne.	Do.	5	68	s.
Nashville, Tenn.	29	53	sw.	Do.	7	64	s.
New Haven, Conn.	29	61	nw.	Do.	8	61	s.
New York, N. Y.	9	54	nw.	Do.	19	69	sw.
Do.	10	64	nw.	Do.	20	74	s.
Do.	13	66	n.	Do.	21	60	sw.
Do.	14	64	nw.	Do.	27	60	s.
Do.	18	64	nw.	Do.	28	58	w.
Do.	25	62	s.	Trenton, N. J.	26	64	w.
Do.	26	90	nw.	Wichita, Kans.	10	52	n.

WEATHER CONDITIONS ON THE NORTH ATLANTIC DURING DECEMBER, 1914.

The data presented are for December, 1914, and comparison and study of the same should be in connection with those appearing in the REVIEW for that month. Chart IX (XLIII–140) shows for December, 1914, the averages of pressure, temperature, and the prevailing direction of the wind at 7 a. m., seventy-fifth meridian time, together with the locations and courses of the more severe storms of the month.

PRESSURE.

For the month as a whole the distribution of the atmospheric pressure over the greater part of the ocean differed considerably from the normal, as shown on the Meteorological Chart of the North Atlantic Ocean for December. The Azores high was about 8 degrees west of its normal position, and slightly less in area, and greater in intensity than usual. The isobar of 29.35 inches, showing the lowest mean barometer reading for the month, extended as far south as the fifty-fifth parallel, at a point where the normal pressure is about 29.70 inches. This line marks the southern boundary of the Icelandic low, although there were so few observations received north of the sixtieth parallel and west of the twentieth meridian that it was impossible to plot the center of this area, which was apparently some distance south of its normal position. The distance between the Azores high and the Icelandic low was less and the gradient between them greater than usual; the number of days with heavy winds and disturbed conditions was much above the average in the area between these two great centers of action.

STORMS.

Along the middle and eastern portions of the northern sailing routes the Meteorological Chart of the North Atlantic for December shows that the highest normal percentage of gales of 48 miles an hour or over, for any one 5-degree square, is 30. For December, 1914, there were several squares in the same general locality where gales were reported on from 17 to 18 days, or a percentage of 55 and 58, respectively. There was not a single day that winds of gale force were not reported on some part of the ocean north of the fortieth parallel, and in marine circles the month was considered as being unusual for its stormy character.

Only two storm tracks are shown on Chart IX, as the center of many of the lows from which the gales originated were too far north to plot, and in other cases the movements of the storms were either too uncertain or there were not enough observations received for an accurate determination of their positions.

On December 7 a low (I on Chart IX) appeared about 4 degrees east of Hatteras. The winds were moderate and variable near its center and south of it, although vessels between the thirty-eighth and forty-second parallels, and the coast and sixtieth meridian, reported easterly and northeasterly winds of from 48 to 64 miles an hour, with hail and rain. The disturbance moved slowly along the coast in a northeasterly direction and on the 8th was east of New York, near the sixty-sixth meridian. Several vessels a short distance north of the center reported winds of high velocities, although the storm area was less than on the previous day. Between the 8th and 9th the disturbance increased its rate of movement and on the latter date was central near latitude 45° and longitude 40°. While the barometer had fallen somewhat since the day before, the wind had apparently decreased slightly, a maximum velocity of 48 miles being reported by vessels between the forty-sixth and sixty-second meridians, snow, rain, and hail occurring near the forty-sixth parallel between the fortieth and fifty-sixth meridians. The storm traveled in a north by east direction with decreasing speed and on the 10th was near latitude 50° and longitude 46°, the barometer having fallen to 28.76 inches, while the wind and weather conditions had changed but little. From this point it increased in violence, and on the 11th the barometer reading was 28.40 inches at its center, near latitude 51°, longitude 18°, while in the west and southwest quadrants of the area north and northwest winds of from 40 to 64 miles an hour prevailed. Continuing in nearly the same direction and decreasing in both rate of movement and intensity, the storm was central on December 12 near latitude 50°, longitude 12°. On the 13th it had moved to latitude 49°, longitude 7° W., the barometer having fallen slightly, although the winds within 10 degrees of the center ranged from light to moderate. On the 14th it was central near Holyhead, England, and on the 15th the center was between Shields and Yarmouth, on the east coast of England. The wind velocities on these two days were somewhat higher than on the 13th, the maximum force reported being 48 miles an hour, with rain and hail over a large portion of the area.

On the chart of tracks of low areas for December, 1914 (XLII–86), a low (II on Chart IX) is shown that first appeared on the chart on December 17 in northern Saskatchewan. This moved in a southeasterly direction until the night of the 18th, when it was near White River, Ontario, thence changing to a nearly due easterly course it reached the Gulf of St. Lawrence on the morning of the 20th, moderate north and northwest winds prevailing along the American coast as far south as Philadelphia. The rate of movement during the next 24 hours was very rapid, and on the 21st it was central near latitude 42°, longitude 32°. The barometer fell to 29.06 inches and the wind increased, as all vessels between the thirtieth and fiftieth meridians, north of the forty-fifth parallel, reported southwest to northwest gales of from 40 to 64 miles an hour. On December 22 the center was near latitude 54°, longitude 23°, the barometer having risen slightly since the 21st, while the force of the wind remained about the same, with hail, rain, and snow prevailing over a large part of the area.

On the 29th there was a low, whose apparent center was near latitude 50° and longitude 25°, where the lowest barometer reading was 29.13 inches. A number of vessels between the thirty-sixth and forty-second meridians reported northwesterly winds of from 54 to 90 miles an hour, the latter being the highest velocity reported during the month. On the 30th the center had moved off the limits of the chart, although winds of gale force were reported between the twenty-fifth and thirty-seventh meridians, accompanied by rain, hail, and snow.

TEMPERATURE.

The temperature departures of the air over the ocean, taken as a whole, were irregular. North of the fortieth parallel and between the fifteenth and fiftieth meridians, the temperatures were from 1 to 7 degrees (F.) below the

normal, while in the waters adjacent to the European coast the departures ranged from 4 to 8 above.

Off the American coast north of the fortieth parallel the temperatures were lower than usual. South of that line they were somewhat above the normal, decreasing as the shore was approached, the departures being negative at a number of Weather Bureau stations on the Atlantic coast, as shown in the following list: Eastport, −1.7°F.; Portland, −2.7°; Boston, −1.2°; New York, −2.9°; Norfolk, −3.0°; Hatteras, −0.8°; Washington, −1.6°; Charleston, −2.5°; Jacksonville, −0.6°; Miami, +1.5°; Key West, +1.3°; Tampa, +1.7°; Pensacola, −3.1°; New Orleans, −3.6°; Galveston, −6.1°; and Corpus Christi, −5.8°.

The lowest temperature reported for the month over the ocean was 16° F., and occurred in the 5-degree square adjacent to the Canadian coast, between the fiftieth and fifty-fifth parallels. The highest temperature recorded, 83°, occurred on three different days in the 5-degree square between latitude 10° and 15° and longitude 80° and 85° W.

FOG.

The number of days on which fog was observed was considerably below the normal, as it only occurred on the first four days of the month between the fortieth and forty-fifth parallels, west of the forty-seventh meridian, while it was reported by one vessel on the 25th near latitude 50°, longitude 12°, and again on the 30th near latitude 45°, longitude 50°.

PRECIPITATION.

The number of days on which hail and snow occurred on the northern sailing routes was greatly above the average, as hail was reported on 25 days and snow on 23, while both hail and snow occurred on 20 days.

CONDENSED CLIMATOLOGICAL SUMMARY.

In the following table are given for the various sections of the climatological service of the Weather Bureau the monthly average temperature and total rainfall; the stations reporting the highest and lowest temperatures, with dates of occurrence; the stations reporting the greatest and least total precipitation; and other data, as indicated by the several headings.

The mean temperature for each section, the highest and lowest temperatures, the average precipitation, and the greatest and least monthly amounts are found by using all trustworthy records available.

The mean departures from normal temperatures and precipitation are based only on records from stations that have 10 or more years of observations. Of course the number of such records is smaller than the total number of stations.

Condensed climatological summary of temperature and precipitation by sections, December, 1915.

Section.	Temperature.							Precipitation.					
	Section average.	Departure from the normal.	Monthly extremes.					Section average.	Departure from the normal.	Greatest monthly.		Least monthly.	
			Station.	Highest.	Date.	Station.	Lowest. Date.			Station.	Amount.	Station.	Amount.
	° F.	° F.		° F.			° F.	Ins.	Ins.		Ins.		Ins.
Alabama	46.8	+0.8	Daphne	79	16	Cordova	14 6	6.21	+1.63	Cordova	11.42	Alaga	1.66
Arizona	43.5	+0.6	Cavecreek (near)	87	5	St. Michaels	−14 28	2.71	+1.39	Allen Lake, Ranger station.	9.50	Yuma	0.12
Arkansas	43.9	+2.4	Eldorado	78	21	Dodd City	11 16	4.73	+0.72	Jonesboro	9.60	Fort Smith	1.97
California	45.7	−1.0	2 stations	88	2†	Madeline	−13 30	5.56	+1.53	Branscomb	18.61	3 stations	0.00
Colorado	26.7	+2.4	Las Animas	88	9	Dillon	−33 28	1.22	+0.15	Savage Basin	5.06	Springfield	0.09
Florida	56.6	−2.3	Homestead	86	29	3 stations	23 21†	2.58	−0.39	Satsuma Heights	5.34	Homestead	0.77
Georgia	45.9	−1.0	2 stations	79	16†	Ramhurst	19 21	4.90	+0.73	Clayton	11.65	Hawkinsville	1.36
Hawaii (November)	71.4	.....	3 stations	89	11†	2 stations	47 20†	16.19	.....	Hakalau, Hawaii	55.82	Mahukona, Hawaii	0.94
Idaho	27.0	+0.5	Guffey	65	1	Pierson	−44 30†	2.64	+0.34	Elk Creek	7.24	Oakley	0.25
Illinois	29.9	−0.2	2 stations	63	16	Lincoln	−11 28	2.89	+0.65	Equality	9.08	Dakota	0.18
Indiana	30.8	−0.7	Huntingburg	62	14	Collegeville	− 1 27	4.24	+1.38	Rome	9.38	Notre Dame	0.92
Iowa	25.0	+1.1	Northboro	56	22	6 stations	−10 14†	0.69	−0.53	Storm Lake	1.70	Chariton	T.
Kansas	34.7	+2.5	Richfield	77	9	Coolidge	−11 28	0.59	−0.33	Fort Scott	3.41	3 stations	T.
Kentucky	36.9	−0.6	4 stations	64	16†	Scott	9 15	7.54	+3.75	Calhoun	10.02	Pikeville	5.28
Louisiana	52.8	+1.2	St. Gabriel	88	16	Kelly	18 3	4.25	−0.37	Lakeside	7.38	Reserve	0.99
Maryland-Delaware	33.1	−1.3	Salisbury, Md.	73	29	Oakland, Md	− 6 11	3.16	−0.38	Oakland, Md	4.86	Western Port, Md.	1.70
Michigan	24.4	−0.7	Durand	51	18	Watersmeet	−20 28	1.65	−0.55	Ewen	4.50	Mackinaw	0.65
Minnesota	18.4	+2.5	Redwood Falls	59	8	Angus	−25 27	0.61	−0.27	Littlefork	1.34	Beardsley	0.10
Mississippi	48.5	+0.9	Waynesboro	80	16	Moorhead	18 3	5.73	+0.63	Holly Springs	8.24	Magnolia	3.04
Missouri	34.7	+1.3	Dean	84	3	Lamonte	−13 28	2.77	+0.55	Caruthersville	9.38	Bethany	0.35
Montana	24.7	+1.4	Wheaton	68	4	Bowen	−41 30	0.96	+0.22	Heron	5.01	Penwells Ranch	0.10
Nebraska	28.4	+2.3	Bridgeport	73	22	2 stations	−18 27†	0.71	−0.03	Hay Springs	2.42	Plainview	0.10
Nevada	32.7	+1.8	Las Vegas	81	2	San Jacinto	−28 30	0.93	−0.24	Mariette Lake	6.03	Battle Mountain	0.02
New England	27.4	+0.9	Chestnut Hill, Mass.	62	26	Enosburg Falls, Vt.	−23 31	4.34	+0.91	Cream Hill, Conn	7.52	Patten, Me.	2.40
New Jersey	31.9	−1.2	Moorestown	64	26	Charlotteburg	3 22	4.82	+0.99	Little Falls	7.83	Vineland	2.19
New Mexico	36.5	+1.8	Deming	82	8	Elizabethtown	−28 28	0.80	+0.04	Chama	3.10	Bluewater	T.
New York	25.8	−0.4	Setauket	59	26	Indian Lake	−23 31	4.24	+1.07	Adams Center	11.33	Avon	1.07
North Carolina	39.8	−2.1	Greenville	78	29	Jefferson	10 7	4.39	+0.66	Highlands	14.32	Sanatarium	0.94
North Dakota	15.7	+2.8	Mott	57	8	Willow City	−27 17	0.53	+0.02	Hansboro	2.10	Orange	0.00
Ohio	30.4	−0.9	Ironton	62	17	Vickery	1 29	3.84	+0.82	Syracuse	6.65	Montpelier	1.33
Oklahoma	43.0	+3.9	Eldorado	79	15	Hooker	−15 28	0.78	−0.62	Calvin	3.57	2 stations	0.00
Oregon	37.1	+0.2	Pendleton	67	8	2 stations	−21 30†	5.41	+1.40	Glenora	29.16	Beckley	0.02
Pennsylvania	29.4	−1.5	Lebanon	70	25	Honesdale	− 7 31	4.06	+0.82	Drifton	6.53	Mount Pocono	1.36
Porto Rico	75.8	+1.1	3 stations	95	6†	Aibonita	53 13	5.30	+0.25	Rio Grande (El Verde).	45.14	3 stations	0.00
South Carolina	44.2	−2.2	2 stations	79	29	2 stations	17 21†	3.27	−0.15	Mountain Rest	10.08	Columbia	1.41
South Dakota	24.0	+2.3	Cottonwood	70	7	McIntosh	−21 31	0.55	−0.08	Dumont	1.78	Murdo	T.
Tennessee	40.7	+1.3	Ashwood	73	16	Mountain City	8 15	7.01	−2.69	Perryville	9.83	Mountain City	4.32
Texas	52.0	+3.3	5 stations	90	4†	Stratford	−12 28	1.95	−0.46	Sugarland	7.14	4 stations	0.00
Utah	28.3	+2.0	2 stations	68	4†	Scofield	−21 19	1.26	+0.25	Moab	5.75	Randolph	0.05
Virginia	35.8	−1.3	Ivor	76	29	Fredericksburg (near).	6 15	2.96	−0.23	Elk Knob	6.62	Wachapreague	0.52
Washington	33.8	0.0	Dayton	67	21	Newport	−20 30	6.75	+1.71	Forks	27.88	Odessa	1.05
West Virginia	32.8	−0.8	4 stations	68	17†	2 stations	0 11	4.35	+1.09	Pickens	7.19	Upper Tract	1.35
Wisconsin	21.7	+1.3	La Crosse	50	7	Long Lake	−24 28	0.77	−0.75	Rest Lake	1.99	Darlington	0.14
Wyoming	23.8	+2.1	Wheatland	76	9†	Moran	−46 31	0.92	+0.10	Sand Lake	3.47	Hyattville	0.00

† Other dates also.

DESCRIPTION OF TABLES AND CHARTS.

Table I gives the data ordinarily needed for climatological studies for about 158 Weather Bureau stations, making simultaneous observations at 8 a. m. and 8 p. m., daily, 75th meridian time, and for about 41 others making only one observation. The altitudes of the instruments above ground are also given.

Table II gives a record of precipitation, the intensity of which at some period of the storm's continuance equaled or exceeded the following rates:

Duration (minutes)	5	10	15	20	25	30	35	40	45	50	60
Rates per hour (inches)	3.00	1.80	1.40	1.20	1.08	1.00	0.94	0.90	0.87	0.84	0.80

It is impracticable to make this table sufficiently wide to accommodate on one line the record of accumulated falls that continue at an excessive rate for several hours. In this case *the record is broken at the end of each 50 minutes*, the accumulated amounts being recorded on successive lines until the excessive rate ends.

In cases where no storm of sufficient intensity to entitle it to a place in the full table has occurred the greatest precipitation of any single storm has been given, also the greatest hourly fall during that storm.

The tipping-bucket mechanism is *dismounted* and removed when there is danger of snow or water freezing in the same. Table II records this condition by entering an asterisk (*).

Table III gives, for about 30 stations of the Canadian Meteorological Service, the means of pressure and temperature, total precipitation and depth of snowfall, and the respective departures from normal values except in the case of snowfall.

Chart I.—Hydrographs for several of the principal rivers of the United States.

Chart II.—Tracks of centers of high areas; and

Chart III.—Tracks of centers of low areas. The roman numerals show the chronological order of the centers. The figures within the circles show the days of the month; the letters *a* and *p* indicate, respectively, the observations at 8 a. m. and 8 p. m., 75th meridian time. Within each circle is also given (Chart II) the last three figures of the highest barometric reading or (Chart III) the lowest reading reported at or near the center at that time, and in both cases as reduced to sea level and standard gravity.

Chart IV.—Temperature departures. This chart presents the departures of the monthly mean temperatures from the monthly normals. The normals used in computing the departures were computed for a period of 33 years (1873 to 1905) and are published in Weather Bureau Bulletin "R," Washington, 1908. Stations whose records were too short to justify the preparation of normals in 1908 have been provided with normals as adequate records became available, and all have been reduced to the 33-year interval 1873–1905. The shaded portions of the chart indicate areas of positive departures and unshaded portions indicate areas of negative departures. Generalized lines connect places having approximately equal departures of like sign. This chart of monthly temperature departures in the United States was first published in the MONTHLY WEATHER REVIEW for July, 1909.

Chart V.—Total precipitation. The scale of shades showing the depth is given on the chart. Where the monthly amounts are too small to justify shading, and over sections of the country where stations are too widely separated or the topography is too diversified to warrant reasonable accuracy in shading, the actual depths are given for a limited number of representative stations. Amounts less than 0.005 inch are indicated by the letter T, and no precipitation by 0.

Chart VI.—Percentage of clear sky between sunrise and sunset. The average cloudiness at each Weather Bureau station is determined by numerous personal observations between sunrise and sunset. The difference between the observed cloudiness and 100 is assumed to represent the percentage of clear sky, and the values thus obtained are the basis of this chart. The chart does not relate to the nighttime.

Chart VII.—Isobars and isotherms at sea level and prevailing wind directions. The pressures have been reduced to sea level and standard gravity by the method described by Prof. Frank H. Bigelow on pages 13–16 of the REVIEW for January, 1902. The pressures have also been reduced to the mean of the 24 hours by the application of a suitable correction to the mean of the 8 a. m. and 8 p. m. readings at stations taking two observations daily, and to the 8 a. m. or the 8 p. m. observation, respectively, at stations taking but a single observation. The diurnal corrections so applied will be found in the Annual Report of the Chief of the Weather Bureau, 1900–1901, volume 2, Table 27, pages 140–164.

The isotherms on the sea-level plane have been constructed by means of the data summarized in chapter 8 of volume 2 of the annual report just mentioned. The correction, t_0-t, or temperature on the sea-level plane minus the station temperature as given by Table 48 of that report, is added to the observed surface temperature to obtain the adopted sea-level temperature.

The prevailing wind directions are determined from hourly observations at the great majority of the stations; a few stations having no self-recording wind-direction apparatus determine the prevailing direction from the daily or twice-daily observations only.

Chart VIII.—Total snowfall. This is based on the reports from regular and cooperative observers and shows the depth in inches and tenths of the snowfall during the month. In general, the depth is shown by lines inclosing areas of equal snowfall, but in special cases figures are also given. Chart VIII is published only when the general snow cover is sufficiently extensive to justify its preparation.

Chart IX.—Average values of pressure, temperature, and prevailing wind directions, and storm tracks over the North Atlantic Ocean, *for the corresponding month of last year.*

TABLE I.—*Climatological data for United States Weather Bureau stations, December, 1915.*

Districts and stations.	Elevation of instruments.			Pressure.			Temperature of the air.										Mean wet thermometer.	Mean temperature of the dew point.	Mean relative humidity.	Precipitation.			Wind.								Clear days.	Partly cloudy days.	Cloudy days.	Average cloudiness.	Total snowfall.	Snow on ground at end of month.
	Barometer above sea level.	Thermometer above ground.	Anemometer above ground.	Station, reduced to mean of 24 hours.	Sea level, reduced to mean of 24 hours.	Departure from normal.	Mean max.+mean min.÷2.	Departure from normal.	Maximum.	Date.	Mean maximum.	Minimum.	Date.	Mean minimum.	Greatest daily range.					Total.	Departure from normal.	Days with 0.01 or more.	Total movement.	Prevailing direction.	Maximum velocity. Miles per hour.	Maximum velocity. Direction.	Maximum velocity. Date.							
	Ft.	*Ft.*	*Ft.*	*In.*	*In.*	*In.*	°*F.*	°*F.*	°*F*		°*F*	°*F.*		°*F*	°*F.*		°*F.*	°*F.*	%	*In.*	*In.*		*Miles*										*0–10*	*In.*	*In.*
New England.					**30.5**	**+ 1.1**													**76**	**4.05**	**+ 0.7**												**6.6**		
Eastport	76	67	85	29.75	29.84	−0.14	29.6	+ 4.3	53	26	35	7	31	24	23		27	23	77	3.82	− 0.2	13	10,529	w.	63	ne.	14	4	5	22	7.7	4.4	1.0
Greenville	1,070	6	....	28.68	29.89	.....	22.0	.....	44	26	28	− 1	31	16	23		.....	.....	.....	4.84	.....	15	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	24.3	11.0
Portland, Me.	103	82	117	29.79	29.92	− .11	29.4	+ 2.3	50	26	35	12	31	24	23		26	20	70	4.87	+ 1.2	10	7,301	nw.	54	nw.	26	11	7	13	5.8	12.1	5.0
Concord	288	70	79	29.60	29.93	+ .13	27.8	+ 1.4	55	26	34	11	31	22	29		.....	.....	.....	3.42	+ 0.1	12	4,476	nw.	40	nw.	26	12	3	16	6.1	14.2	4.4
Burlington	404	11	48	29.51	29.97	− .08	25.2	+ 2.7	44	25	30	− 5	31	20	22		.....	.....	.....	2.61	+ 0.9	12	8,581	s.	42	s.	17	2	5	24	8.5	24.2	8.7
Northfield	876	12	60	28.99	29.97	− .08	22.3	+ 1.8	48	26	30	−15	31	15	32		20	18	88	2.76	0.0	11	5,359	n.	35	nw.	26	3	4	24	8.2	24.5	12.2
Boston	125	115	188	29.79	29.93	− .12	34.2	+ 2.6	61	18	40	16	31	28	31		30	26	74	3.94	+ 0.5	12	8,849	w.	52	no.	13	13	4	14	5.4	6.7	4.0
Nantucket	12	14	90	29.90	29.91	− .14	35.6	− 1.1	55	18	41	21	11	30	23		33	29	77	3.87	+ 0.2	14	13,504	nw.	72	sw.	14	4	12	15	6.7	3.2	....
Block Island	26	11	46	29.91	29.94	− .12	35.0	− 1.6	57	18	40	20	12	30	25		32	29	77	4.91	+ 1.1	12	17,159	nw.	86	w.	26	8	4	19	7.0	0.1	....
Narragansett Pier	.....	9	.....	.....	.....	.....	32.3	− 0.2	56	18	40	11	12	25	25		.....	.....	.....	4.93	.....	12	.....	nw.	.....	.....	.....	16	5	10	.....	4.1	0.6
Providence	160	215	251	29.75	29.93	− .13	31.7	+ 0.1	59	18	38	14	12	25	27		29	25	79	3.80	− 0.1	10	11,045	nw.	82	nw.	26	11	9	11	5.5	3.5	2.2
Hartford	159	122	140	29.78	29.97	− .10	30.4	+ 0.6	56	26	37	11	31	24	30		27	23	75	4.78	+ 1.2	10	6,007	nw.	58	nw.	26	5	12	14	6.5	20.0	2.2
New Haven	106	117	155	29.84	29.97	− .10	32.0	+ 0.2	55	26	38	15	31	26	27		28	22	71	5.78	+ 2.1	10	7,314	nw.	61	nw.	26	9	12	10	5.6	18.0	2.7
Middle Atlantic States.					**34.0**	**− 1.2**													**72**	**3.64**	**+ 0.5**												**6.3**		
Albany	97	102	115	29.88	29.99	− .09	28.2	+ 0.7	46	26	34	2	31	23	25		26	22	79	6.35	+ 3.8	12	5,997	nw.	29	nw.	26	8	6	17	6.9	40.3	9.4
Binghamton	871	10	69	29.03	29.99	− .10	27.4	− 0.3	48	25	32	2	12	22	26		.....	.....	.....	3.82	+ 1.4	15	3,232	nw.	24	nw.	26	0	8	23	8.4	20.1	6.4
New York	314	414	454	29.65	30.01	− .08	33.5	− 0.9	55	18	39	17	31	28	26		29	23	68	4.23	+ 0.8	8	15,885	nw.	90	nw.	26	4	12	15	6.8	8.1	....
Harrisburg	374	94	104	29.66	30.07	− .05	32.1	− 0.7	54	25	37	19	12	27	21		28	23	71	3.35	+ 0.7	10	5,834	nw.	38	nw	26	4	14	13	6.5	4.7	T.
Philadelphia	117	123	190	.....	30.04	− .07	35.0	− 0.7	60	25	41	20	15	29	25		.....	.....	.....	4.22	+ 1.2	9	8,385	nw.	42	nw.	18	12	9	10	.....	6.0	....
Reading	325	81	98	29.69	30.05	.....	32.6	.....	59	25	38	19	12	27	25		28	23	68	4.37	+ 1.0	8	6,404	nw.	30	nw.	26	2	14	15	6.8	8.0	T.
Scranton	895	111	119	29.14	30.02	− .08	29.4	− 0.4	56	25	35	10	12	24	24		27	23	77	4.66	+ 2.0	12	5,749	sw.	34	w.	14	2	9	20	7.9	17.9	2.2
Atlantic City	52	37	48	29.99	30.04	− .06	34.8	− 1.6	55	29	41	20	11	28	23		31	26	75	4.41	+ 0.7	9	6,572	nw.	33	nw.	26	11	6	14	5.9	6.8	....
Cape May	18	13	49	30.06	30.07	− .04	35.6	− 2.4	54	29	41	23	31	30	24		.....	.....	.....	2.42	− 1.4	9	8,189	nw.	38	w.	26	9	13	9	5.3	1.3	....
Sandy Hook	22	10	57	29.98	30.01	.....	33.5	.....	55	18	38	20	15	29	23		31	27	79	4.31	.....	10	15,017	nw.	76	w.	26	8	13	10	5.9	9.8	....
Trenton	190	156	183	29.81	30.02	.....	32.4	.....	60	25	38	18	15	26	26		29	24	75	4.44	+ 1.3	9	9,435	nw.	64	w.	26	6	12	13	6.5	9.5	....
Baltimore	123	103	113	29.94	30.08	− .05	35.4	− 1.5	58	25	41	22	15	30	25		31	25	67	3.08	0.0	8	5,328	nw.	26	e.	29	9	15	7	5.4	4.3	....
Washington	112	62	85	29.95	30.08	− .05	35.2	− 0.9	62	25	42	21	16	29	26		30	25	69	2.80	− 0.4	9	5,711	nw.	40	nw.	26	9	12	10	5.7	3.8	....
Lynchburg	681	153	188	29.32	30.09	− .05	38.0	− 0.3	67	25	46	20	11	30	33		32	25	65	2.37	− 0.9	9	5,632	nw.	37	nw.	26	8	9	14	6.2	2.7	....
Norfolk	91	170	235	29.99	30.09	− .04	40.5	− 2.5	75	29	47	23	15	34	32		35	28	65	2.26	− 1.2	10	10,602	n.	58	w.	25	12	11	8	4.9	4.0	....
Richmond	144	11	52	29.93	30.09	− .05	37.7	− 3.3	71	29	46	19	15	26	33		32	28	73	1.93	− 1.1	9	5,834	s.	50	sw.	25	11	7	13	5.1	0.6	....
Wytheville	2,293	49	55	27.63	30.09	− .06	33.2	− 2.1	57	17	41	16	27	26	32		29	25	77	3.45	− 0.3	9	5,871	w.	40	w.	29	8	9	14	6.4	11.0	....
South Atlantic States.					**45.2**	**− 1.9**													**73**	**2.66**	**− 1.0**												**4.2**		
Asheville	2,253	70	84	27.69	30.13	− .03	37.6	− 0.2	61	29	46	20	21	28	34		32	27	72	5.01	+ 1.0	8	7,450	nw.	44	se.	17	13	8	10	4.9	6.6	....
Charlotte	773	153	161	29.25	30.11	− .05	41.4	− 1.5	66	29	49	26	21	33	31		36	30	70	3.53	− 0.3	10	7,474	sw.	58	sw.	29	17	5	9	4.0	0.4	....
Hatteras	11	12	50	30.08	30.09	− .04	44.8	− 4.0	69	29	51	31	21	38	22		41	37	76	1.80	− 3.3	11	12,189	n.	66	w.	26	11	13	7	4.8	0.4	....
Mantee	12	4	46	.....	.....	.....	41.6	.....	67	29	51	26	22	32	.....		.....	.....	.....	3.12	− 2.1	6	.....	n.	.....	.....	.....	18	7	6	.....	.....	4.0
Raleigh	376	103	110	29.69	30.11	− .04	41.2	− 1.5	72	29	50	26	1	33	33		35	29	66	2.10	− 1.1	9	6,156	sw.	42	sw.	29	9	11	11	5.3	2.3	....
Wilmington	78	81	91	30.03	30.12	− .02	44.5	− 2.7	71	17	53	25	22	36	27		39	34	74	1.81	− 1.3	10	5,461	w.	38	sw.	29	16	6	9	4.0	7.5	....
Charleston	48	11	92	30.08	30.13	− .02	48.2	− 3.1	71	29	56	31	21	40	27		43	38	76	2.81	− 0.3	6	7,343	n.	47	s.	18	18	7	6	3.7	2.5	....
Columbia, S. C.	351	41	57	29.74	30.14	− .02	44.6	− 2.6	73	17	55	29	7	34	36		38	32	70	1.41	− 1.5	5	5,357	sw.	42	sw.	29	20	4	7	3.7	T.	....
Augusta	180	89	97	29.94	30.14	− .02	45.8	− 1.2	73	17	56	27	22	36	33		40	37	79	2.08	− 1.4	8	4,762	w.	40	sw.	29	18	6	7	4.1	T.	....
Savannah	65	150	194	30.07	30.14	− .01	50.4	− 0.9	74	25	60	31	21	41	34		43	38	72	2.08	− 1.0	5	8,391	w.	52	w.	25	13	12	6	4.5	T.	....
Jacksonville	43	209	245	30.09	30.14	.00	53.8	− 1.4	75	17	64	32	21	44	34		46	41	71	3.46	+ 0.5	6	9,202	nw.	46	sw.	25	18	9	4	3.4	.....	....
Florida Peninsula.					**64.1**	**− 1.7**													**77**	**2.18**	**+ 0.2**												**4.3**		
Key West	22	10	64	30.06	30.08	.00	68.4	− 1.7	82	29	73	55	15	64	17		63	60	79	2.14	+ 0.3	6	8,481	ne.	56	n.	20	18	7	6	3.7	.....	....
Miami	25	71	79	30.08	30.11	.....	65.6	− 2.4	79	29	72	47	23	56	25		60	57	77	2.00	− 0.2	8	6,919	nw.	38	nw.	20	11	8	12	5.6	.....	....
Sand Key	23	39	72	30.03	30.06	− .02	69.2	.....	79	29	72	55	21	66	15		65	62	80	1.83	.....	6	13,710	ne.	66	nw.	20	16	9	6	4.0	.....	....
Tampa	35	79	96	30.09	30.13	+ .01	58.4	− 1.1	79	30	68	37	22	48	32		51	46	73	2.41	+ 0.4	5	5,244	n.	30	nw.	20	17	8	6	3.9	.....	....
East Gulf States.					**49.6**	**+ 0.4**													**77**	**5.54**	**+ 1.0**												**5.5**		
Atlanta	1,174	190	216	28.86	30.12	− .04	43.7	− 0.9	63	24	52	27	21	36	27		39	34	73	9.07	+ 4.5	10	8,954	nw.	42	nw.	17	10	6	15	5.9	T.	....
Macon	370	78	87	29.73	30.14	− .02	46.2	− 0.6	72	17	57	26	1	36	32		41	37	77	3.10	− 1.3	7	4,375	nw.	34	sw.	29	16	5	10	4.4	.....	....
Thomasville	273	8	57	29.83	30.14	− .01	50.8	− 1.7	74	17	64	26	22	38	35		43	39	80	1.73	− 2.0	8	3,771	nw.	31	sw.	29	13	10	8	4.4	0.1	....
Pensacola	56	140	182	30.06	30.12	− .03	54.8	+ 0.9	72	11	63	35	3	47	23		50	45	75	4.93	+ 0.8	8	10,456	ne.	70	sw.	28	10	13	8	4.8	.....	....
Anniston	741	9	57	29.33	30.14	− .02	44.1	− 0.1	69	16	55	22	21	33	33		.....	.....	.....	6.44	+ 1.9	11	4,291	se.	40	sw.	29	11	5	15	5.9	T.	....
Birmingham	700	11	48	29.35	30.14	− .02	46.7	− 0.6	71	16	55	27	3	38	27		40	35	71	6.11	+ 1.5	11	5,609	s.	38	sw.	29	7	10	14	6.3	T.	....
Mobile	57	125	161	30.05	30.11	− .04	53.8	+ 2.3	75	11	63	34	21	45	28		49	46	81	4.16	− 0.4	9	7,430	se.	50	sw.	28	8	17	6	5.2	.....	....
Montgomery	223	100	112	29.89	30.14	− .02	49.6	+ 0.5	75	16	59	30	21	40	28		43	38	71	7.79	+ 3.3	9	4,780	se.	39	sw.	28	10	11	10	5.0	.....	....
Meridian	375	85	93	29.70	30.11	− .05	48.4	+ 1.5	76	16	58	27	3	38	30		44	41	81	6.77	+ 1.6	10	4,185	nw.	38	w.	28	8	7	16	6.6	.....	....
Vicksburg	247	65	74	29.82	30.11	− .04	50.4	+ 1.0	75	16	59	30	18	42	27		45	41	77	5.77	+ 0.8	9	5,725	se.	28	nw.	24	12	2	17	5.9	T.	....
New Orleans	51	76	84	30.04	30.10	− .03	56.7	+ 2.3	77	31	65	36	29	48	31		52	49	81	5.07	+ 0.6	11	5,581	se.	32	w.	28	9	7	15	6.0	.....	....
West Gulf States.					**51.9**	**+ 2.8**													**73**	**3.04**	**+ 0.2**												**5.3**		
Shreveport	249	77	93	29.81	30.09	− .04	50.4	+ 1.5	75	15	60	30	29	41	31		45	41	75	3.05	− 1.3	9	6,119	se.	37	nw.	24	13	2	16	5.7	0.9	....
Bentonville	1,303	11	44	28.64	30.03	− .10	41.0	+ 3.5	65	9	51	18	28	32	31		.....	.....	.....	3.78	+ 1.0	7	4,673	nw.	28	s.	26	12	6	13	5.7	2.0	....
Fort Smith	457	79	94	29.55	30.05	− .08	44.2	+ 2.5	69	10	53	26	20	35	34		39	33	69	1.97	− 0.9	6	7,399	e.	46	nw.	11	9	6	16	6.3	.....	....
Little Rock	357	139	147	29.69	30.08	− .06	46.0	+ 2.5	70	15	54	28	3	38	29		40	35	70	5.37	+ 1.1	11	7,119	nw.	38	s.	26	9	5	17	6.7	.....	....
Brownsville	57	3	40	.....	.....	.....	65.2	.....	83	31	75	35	21	55	39		.....	.....	.....	4.30	.....	7	.....	s.	.....	.....	.....	.....	.....	.....	.....	.....	.....	....
Corpus Christi	20	69	77	30.03	30.05	− .07	61.2	+ 4.6	79	4	70	37	28	53	31		56	53	81	0.87	− 0.4	7	9,096	se.	40	s.	27	13	11	7	4.6	.....	....
Dallas	512	109	117	29.50	30.06	.....	50.1	.....	75	10	60	22	29	40	33		.....	.....	.....	2.52	.....	7	7,968	se.	40	nw.	24	15	5	11	4.9	0.6	....
Fort Worth	670	106	114	29.31	30.03	− .09	50.9	+ 3.4	76	10	62	22	29	40	36		43	36	65	1.99	+ 0.8	6	8,408	nw.	50	nw.	24	14	5	12	5.0	1.5	....
Galveston	54	106	114	30.02	30.08	− .04	57.9	+ 1.6	74	5	64	35	28	52	25		55	51	80	5.69	+ 2.0	12	9,564	s.	48	se.	7	13	5	13	5.0	.....	....
Houston	138	111	121	29.92	30.07	.....	56.8	+ 2.3	76	5	66	30	29	47	34		.....	.....	.....	6.12	.....	10	6,855	se.	31	nw.	24	10	7	14	5.8	.....	....
Palestine	510	64	72	29.52	30.06	− .06	52.0	+ 2.6	75	15	61	26	29	43	31		47	43	78	3.77	+ 0.1	10	6,370	s.	37	e.	6	14	4	13	5.3	2.0	....
San Antonio	701	109	132	29.31	30.05	− .06	56.8	+ 3.7	83	31	68	30	29	46	37		49	43	67	1.57	0.0	6	.....	ne.	41	n.	24	14	11	6	3.9	.....	....
Taylor	582	55	63	29.46	30.08	− .03	53.6	+ 3.0	80	31	64	27	29	43	37		.....	.....	.....	2.44	− 0.2	8	7,905	s.	37	s.	26	14	6	11	4.7	T.	....

TABLE 1.—*Climatological data for United States Weather Bureau stations, December, 1915*—Continued.

Districts and stations.	Elevation of instruments.			Pressure.			Temperature of the air.											Mean wet thermometer.	Mean temperature of the dew point.	Mean relative humidity.	Precipitation.			Wind.								Clear days.	Partly cloudy days.	Cloudy days.	Average cloudiness.	Total snowfall.	Snow on ground at end of month.
	Barometer above sea level.	Thermometer above ground.	Anemometer above ground.	Station, reduced to mean of 24 hours.	Sea level, reduced to mean of 24 hours.	Departure from normal.	Mean max.+mean min.÷2.	Departure from normal.	Maximum.	Date.	Mean maximum.	Minimum.	Date.	Mean minimum.	Greatest daily range.					Total.	Departure from normal.	Days with 0.01 or more.	Total movement.	Prevailing direction.	Maximum velocity. Miles per hour.	Maximum velocity. Direction.	Maximum velocity. Date.								
	Ft.	*Ft.*	*Ft.*	*In.*	*In.*	*In.*	°*F.*	°*F.*	°*F*		°*F*	°*F.*		°*F*	°*F.*	°*F.*	°*F.*	%	*In.*	*In.*		*Miles.*								*0–10*	*In.*	*In.*
Ohio Valley and Tennessee.							**35.6**	**− 1.2**										**78**	**5.78**	**+ 2.4**										**7.5**		
Chattanooga	762	189	213	29.31	30.14	−0.02	42.0	− 0.6	62	23	49	27	21	34	27	37	31	70	8.53	+ 4.2	11	5,788	s.	59	sw.	29	5	10	16	6.7	T.	....
Knoxville	996	93	100	29.03	30.12	− .04	39.8	+ 0.1	63	17	48	21	21	32	32	35	31	75	7.77	+ 3.6	10	3,775	sw.	38	sw.	29	6	11	14	6.9	2.5	....
Memphis	399	76	97	29.67	30.11	− .04	45.0	+ 1.5	70	16	52	26	28	38	28	41	36	74	5.73	+ 1.4	12	6,856	s.	36	nw.	16	8	6	17	6.6	1.3	....
Nashville	546	168	191	29.51	30.11	− .04	42.4	+ 1.3	69	16	50	26	21	34	33	37	32	73	6.44	+ 2.6	14	7,639	w.	53	sw.	29	7	9	15	6.5	0.2	....
Lexington	989	193	230	28.98	30.08	− .06	35.9	− 0.5	60	17	43	20	14	29	31	....	....	....	6.67	+ 3.4	13	10,776	sw.	56	sw.	29	8	6	17	6.9	2.6	....
Louisville	525	219	255	29.51	30.11	− .03	36.7	− 1.4	58	17	43	22	14	30	30	33	28	76	8.43	+ 4.7	13	9,013	s.	44	sw.	25	5	8	18	7.1	6.2	....
Evansville	431	72	82	29.60	30.08	− .05	36.8	+ 0.4	60	16	43	20	28	30	28	34	30	80	6.97	+ 3.1	13	6,041	w.	45	s.	26	7	9	15	6.5	5.1	T.
Indianapolis	822	194	230	29.16	30.08	− .04	31.0	− 1.6	48	17	37	13	14	25	21	28	26	81	5.15	+ 2.1	13	9,011	w.	37	w.	23	3	9	19	7.6	13.1	3.5
Terre Haute	575	96	129	29.43	30.07	.....	32.4	− 4.0	49	17	38	14	28	26	23	29	26	81	4.59	.....	14	7,506	nw.	32	nw.	8	0	17	14	7.4	7.9	2.2
Cincinnati	628	11	51	29.39	30.09	− .04	32.7	− 3.7	55	17	40	14	15	26	34	30	27	82	4.59	+ 1.7	12	6,555	ne.	35	sw.	25	5	8	18	7.6	5.6	T.
Columbus	824	173	222	29.18	30.08	− .04	31.0	− 1.8	52	17	36	13	15	26	21	28	25	76	4.15	+ 1.4	14	8,990	s.	50	w.	23	1	6	24	8.8	5.1	T.
Dayton	899	181	216	29.07	30.06	.....	31.6	− 1.5	54	17	38	11	15	26	28	29	26	82	3.30	+ 0.7	15	8,519	sw.	37	w.	23	1	9	21	7.7	4.6	0.4
Pittsburgh	842	353	410	29.13	30.07	− .04	31.8	− 2.9	58	17	38	16	15	26	27	29	26	78	3.85	+ 1.1	17	9,514	w.	46	nw.	26	0	5	26	8.9	8.0	....
Elkins	1,940	41	50	27.96	30.11	− .01	30.1	− 2.4	57	25	38	2	11	22	35	27	24	83	4.04	+ 0.6	18	3,452	w.	22	s.	25	0	6	25	8.7	12.9	....
Parkersburg	638	77	84	29.43	30.11	− .03	34.2	− 1.0	58	17	40	18	15	28	26	31	28	79	5.24	+ 2.5	14	4,611	nw.	34	nw.	8	1	9	21	8.5	4.9	....
Lower Lake Region.							**28.1**	**− 1.0**										**81**	**2.97**	**+ 0.1**										**8.4**		
Buffalo	767	247	280	29.15	30.01	− .05	27.8	− 2.3	48	25	32	16	15	23	25	26	24	84	4.09	+ 0.7	21	14,064	w.	54	w.	23	1	6	24	8.7	27.2	10.0
Canton	448	10	61	29.49	29.99	.....	23.1	+ 0.4	44	25	29	− 6	31	17	28	....	....	....	2.49	− 1.1	19	6,811	w.	34	e.	29	5	4	22	7.9	18.0	5.3
Oswego	335	76	91	29.61	30.00	− .06	28.0	− 1.2	45	25	33	7	31	23	22	27	24	83	3.78	+ 0.2	20	9,345	s.	36	nw.	26	1	3	27	9.0	36.6	4.5
Rochester	523	97	113	29.43	30.02	− .04	28.0	− 0.9	48	25	33	11	31	23	22	26	22	77	2.21	− 0.7	22	7,235	w.	27	w.	14	1	4	26	9.0	14.8	3.5
Syracuse	597	97	113	29.34	30.01	− .06	27.1	− 1.2	47	25	32	6	12	22	25	25	22	81	5.07	+ 2.4	20	9,142	s.	48	nw.	26	3	3	25	8.5	39.5	8.0
Erie	714	130	166	29.23	30.02	− .05	30.0	− 1.7	50	25	34	16	20	26	21	28	24	78	3.12	+ 0.1	17	12,304	nw.	52	se.	17	0	2	29	9.1	25.3	7.6
Cleveland	762	190	201	29.20	30.05	− .04	30.8	− 0.3	52	25	35	17	15	27	22	28	25	80	1.75	− 0.8	15	11,373	nw.	47	nw.	14	0	3	28	9.2	9.4	2.5
Sandusky	629	62	103	29.36	30.06	− .03	30.0	− 1.1	52	17	34	15	15	26	21	28	25	80	2.61	+ 0.3	11	10,075	w.	44	ne.	29	3	7	21	8.0	14.0	7.0
Toledo	628	208	243	29.36	30.07	− .01	29.4	− 1.1	46	17	34	17	15	25	17	27	24	79	2.50	+ 0.2	10	10,628	sw.	44	n.	29	5	7	19	7.6	13.8	6.5
Fort Wayne	856	113	124	29.12	30.08	.....	27.6	+ 0.3	42	23	33	10	15	22	25	26	23	83	1.78	.....	13	7,514	sw.	35	ne.	29	2	8	21	8.0	17.9	6.3
Detroit	730	218	245	29.24	30.06	− .01	27.8	− 1.7	41	22	33	13	14	23	17	26	24	82	2.08	− 0.3	14	9,327	w.	37	w.	23	4	5	22	7.8	13.9	4.5
Upper Lake Region.							**24.8**	**+ 0.3**										**84**	**1.34**	**− 0.8**										**7.8**		
Alpena	609	13	92	29.34	30.03	+ .01	25.0	+ 0.2	36	23	30	9	29	20	23	24	22	86	1.23	− 1.0	13	8,425	nw.	39	se.	17	0	7	24	8.5	9.8	4.0
Escanaba	612	54	60	29.56	30.05	+ .02	24.3	+ 2.7	36	7	30	− 1	28	18	23	23	20	82	2.03	+ 0.3	9	6,149	nw.	27	s.	7	4	11	16	7.1	18.0	5.0
Grand Haven	632	54	92	29.34	30.05	.00	27.6	− 2.5	42	22	33	11	4	22	23	26	23	83	1.15	− 1.4	15	8,314	e.	42	w.	23	3	10	18	7.7	8.9	T.
Grand Rapids	707	70	87	29.27	30.07	+ .02	27.0	− 1.8	41	23	32	12	4	22	20	25	22	83	1.22	− 1.3	13	4,678	e.	22	w.	23	1	9	21	8.2	12.6	1.0
Houghton	684	62	72	29.28	30.03	+ .01	23.2	+ 2.3	38	7	29	2	22	17	30	....	....	....	2.50	0.0	18	4,762	nw.	25	w.	27	0	2	29	9.4	23.2	10.5
Lansing	878	11	62	29.07	30.04	.....	24.8	− 2.0	39	23	31	8	28	19	21	23	21	88	1.01	− 1.1	15	4,814	sw.	21	ne.	29	6	4	21	7.7	11.0	3.0
Ludington	637	60	66	29.32	30.04	.....	27.4	.....	43	7	33	11	29	22	20	26	23	85	1.50	.....	15	7,562	e.	37	sw.	7	1	6	24	8.7	12.2	2.4
Marquette	734	77	111	29.23	30.06	+ .04	24.6	+ 1.7	36	7	30	9	28	20	16	23	19	81	2.17	− 0.4	17	6,898	w.	29	s.	7	0	8	23	8.8	21.8	10.0
Port Huron	638	70	120	29.32	30.04	− .02	26.4	− 0.9	40	17	31	10	26	21	20	25	23	86	1.84	− 0.3	12	8,999	nw.	34	nw.	9	0	11	20	7.9	16.3	5.5
Saginaw	641	48	82	29.33	30.05	.....	25.0	.....	39	23	31	10	15	19	20	24	23	91	0.94	− 1.0	9	6,723	w.	28	w.	23	2	6	23	8.1	9.4	5.0
Sault Sainte Marie	614	11	61	29.33	30.06	+ .06	21.6	+ 1.1	34	8	27	5	16	16	19	20	17	81	0.89	− 1.4	12	6,191	e.	32	w.	27	5	9	17	7.1	10.3	5.3
Chicago	823	140	310	29.16	30.08	.00	29.1	− 0.2	42	23	34	8	20	24	19	27	23	74	1.31	− 0.8	11	9,302	w.	35	w.	23	5	9	17	7.2	9.2	0.3
Green Bay	617	109	144	29.36	30.05	+ .01	23.4	+ 2.1	40	7	29	− 5	28	18	28	22	18	78	0.86	− 1.0	8	7,035	sw.	33	w.	23	5	5	21	7.8	4.8	1.2
Milwaukee	681	149	133	29.29	30.06	.00	26.8	+ 0.8	39	7	32	4	28	22	23	25	23	82	0.70	− 1.2	8	8,457	w.	38	se.	16	6	10	15	6.6	5.4	1.3
Duluth	1,133	11	47	28.78	30.06	+ .01	18.6	+ 0.9	39	7	24	− 7	27	13	20	18	16	90	0.87	− 0.4	8	8,176	w.	47	w.	23	7	7	17	6.6	8.9	3.3
North Dakota.							**16.9**	**+ 5.0**										**85**	**0.62**	**0.0**										**6.4**		
Moorhead	940	8	57	29.01	30.07	− .01	16.4	+ 5.7	41	7	24	−12	27	8	34	15	13	86	0.58	− 0.2	8	6,070	nw.	28	nw.	26	11	4	16	6.1	5.3	5.3
Bismarck	1,674	8	57	28.20	30.07	− .01	19.8	+ 4.8	44	22	30	− 6	27	10	34	17	14	83	0.39	− 0.2	8	5,954	nw.	41	nw.	23	10	10	11	5.4	4.6	2.6
Devils Lake	1,482	11	44	28.36	30.02	− .04	12.4	+ 4.4	36	22	21	−14	17	3	36	11	10	93	0.64	+ 0.2	9	6,851	se.	33	nw.	26	6	7	18	6.8	6.8	3.9
Williston	1,872	40	47	27.94	29.99	− .07	18.8	+ 5.2	42	3	27	− 7	31	10	26	17	13	77	0.88	+ 0.2	10	5,208	w.	38	nw.	22	4	9	18	7.3	7.7	2.8
Upper Mississippi Valley.							**28.0**	**+ 0.6**										**81**	**1.72**	**− 0.1**										**6.7**		
Minneapolis	918	10	208	29.02	30.04	.....	22.6	.....	47	7	29	− 3	27	16	24	....	....	....	0.46	− 0.5	6	8,611	se.	35	nw.	22	7	10	14	6.4	7.6	2.4
St. Paul	837	201	236	29.12	30.07	− .01	22.6	+ 3.3	47	7	29	− 2	27	16	24	....	....	....	0.53	− 0.5	6	8,786	se.	41	nw.	22	7	8	16	6.7	6.0	2.2
La Crosse	714	11	48	29.26	30.07	− .01	23.5	+ 0.7	50	7	30	0	28	17	22	....	....	....	0.75	− 0.6	4	3,739	nw.	24	w.	23	7	5	19	7.3	5.1	2.5
Madison	974	70	78	28.99	30.08	.00	23.9	+ 1.2	40	7	29	1	28	18	23	22	19	83	0.64	− 1.1	4	6,950	nw.	31	w.	23	5	4	22	7.9	2.6	1.0
Charles City	1,015	10	49	28.96	30.08	− .02	20.8	+ 1.8	47	7	29	−10	14	13	31	19	16	84	1.24	0.0	7	5,135	nw.	28	nw.	23	7	11	13	6.9	11.4	2.5
Davenport	606	71	79	29.40	30.09	− .01	26.1	− 1.1	44	22	32	4	28	20	27	24	21	83	1.13	− 0.6	7	6,324	e.	30	nw.	23	7	7	17	6.7	5.1	0.3
Des Moines	861	84	97	29.12	30.06	− .05	27.8	+ 2.1	54	7	35	7	28	21	32	25	20	74	0.65	− 0.7	6	5,587	nw.	23	e.	10	7	7	17	6.9	2.1	....
Dubuque	698	81	96	29.32	30.11	+ .01	25.5	+ 1.0	44	7	31	3	28	20	23	23	20	80	0.36	− 1.4	6	4,955	nw.	26	nw.	23	5	7	19	7.2	2.0	T.
Keokuk	614	64	78	29.38	30.08	− .07	29.5	+ 0.1	50	22	36	7	28	23	23	27	24	83	1.49	− 0.4	8	.....	w.	33	w.	23	7	12	12	6.1	3.0	T.
Cairo	356	87	93	29.67	30.07	− .08	39.3	+ 0.8	62	16	46	20	28	32	25	35	31	75	6.61	+ 3.3	12	6,685	s.	30	se.	26	8	7	16	6.6	1.5	....
Peoria	609	11	45	29.40	30.09	− .02	27.8	− 0.3	45	8	34	0	28	22	26	26	24	89	1.66	− 0.7	9	5,609	e.	27	w.	23	7	9	15	6.2	7.2	0.8
Springfield, Ill	644	10	91	29.36	30.07	− .05	30.4	− 0.9	50	8	36	6	28	24	21	28	24	80	2.91	+ 0.5	11	6,452	e.	26	ne.	15	6	12	13	6.6	13.4	5.1
Hannibal	534	74	109	29.48	30.08	− .04	31.4	+ 0.1	54	8	38	− 2	28	25	23	....	....	....	2.24	+ 0.6	10	6,724	e.	30	e.	10	11	7	13	5.9	13.2	1.4
St. Louis	567	265	303	29.44	30.06	− .07	35.4	− 0.1	56	22	42	12	28	29	22	32	28	78	3.34	+ 1.1	9	9,430	nw.	36	s.	22	9	8	14	6.2	13.0	3.0
Missouri Valley.							**30.3**	**+ 3.4**										**77**	**1.05**	**0.0**										**5.7**		
Columbia, Mo	781	11	84	29.20	30.06	− .06	33.3	+ 0.4	54	22	40	0	28	27	25	....	....	....	1.67	− 0.3	6	6,693	e.	26	se.	10	5	14	12	6.5	15.1	T.
Kansas City	963	161	181	28.99	30.05	− .07	34.8	+ 3.3	61	22	42	9	29	28	24	30	25	71	1.12	− 0.2	6	8,795	e.	33	nw.	1	12	8	11	5.3	5.2	T.
St. Joseph	967	11	49	28.99	30.06	.....	32.0	.....	59	22	39	4	28	25	25	28	24	75	1.86	.....	7	6,562	nw.	31	nw.	1	8	10	13	6.0	4.4	0.8
Springfield, Mo	1,324	98	104	28.61	30.05	− .08	37.6	+ 2.1	60	22	46	12	28	30	27	33	29	78	3.21	+ 0.5	8	8,451	se.	30	se.	10	14	7	10	4.8	7.2	....
Iola	984	11	50	28.98	30.06	− .06	36.8	+ 4.3	66	15	47	7	28	26	33	....	....	....	1.12	+ 0.2	6	5,268	nw.	25	n.	10	11	10	10	5.0	5.0	....
Topeka	983	85	101	.....	.....	.....	34.0	+ 2.9	64	22	42	3	28	26	30	....	....	....	1.34	+ 0.5	6	6,721	e.	31	nw.	1	11	11	9	5.0	4.6	T.
Drexel	1,299	10	53	28.63	30.06	.....	27.3	.....	53	7	35	5	17	20	31	24	22	84	0.62	.....	6	8,165	nw.	32	sw.	2	9	8	14	6.2	6.8	....
Lincoln	1,189	11	84	28.75	30.06	− .06	29.7	+ 2.8	61	22	38	6	17	22	28	26	22	79	0.98	+ 0.3	6	6,702	e.	37	nw.	18	10	7	14	6.0	7.3	1.1
Omaha	1,105	115	121	28.84	30.07	− .04	29.6	+ 2.5	55	7	36	8	28	23	27	26	22	76	0.34	− 0.6	5	5,997	nw.	31	nw.	26	9	9	13	5.9	2.3	T.
Valentine	2,598	47	54	27.24	30.06	− .04	26.7	+ 2.2	59	9	39	− 6	17	15	40	22	17	74	0.49	− 0.1	6	6,305	w.	37	nw.	1	10	12	9	5.1	4.9	1.2
Sioux City	1,135	94	164	28.82	30.07	− .05	26.7	+ 4.1	50	22	34	2	17	20	28	24	20	78	0.67	− 0.1	7	8,565	nw.	38	nw.	26	11	7	13	5.9	6.0	T.
Huron	1,306	59	74	28.62	30.07	− .03	22.3	+ 6.6	48	6	31	− 8	17	13	29	20	18	86	0.73	+ 0.1	6	7,074	se.	36	nw.	26	9	8	14	5.9	9.2	2.0
Pierre	1,572	70	75	28.35	30. 3	− .02	25.8	+ 5.7	54	22	35	0	17	16	37	22	17	73	0.25	− 0.2	5	5,670	nw.	37	w.	22	9	8	14	6.0	3.4	2.0
Yankton	1,233	49	57	28.69	30.06	− .05	26.6	+ 4.4	51	7	34	1	17	20	26	....	....	....	0.71	0.0	8	5,764	nw.	30	sw.	28	5	10	16	6.8	7.2	1.5

TABLE I.—*Climatological data for United States Weather Bureau stations, December, 1915*—Continued.

Districts and stations.	Elevation of instruments.			Pressure.			Temperature of the air.										Mean wet thermometer.	Mean temperature of the dew point.	Mean relative humidity.	Precipitation.			Wind.						Clear days.	Partly cloudy days.	Cloudy days.	Average cloudiness.	Total snowfall.	Snow on ground at end of month.
	Barometer above sea level.	Thermometer above ground.	Anemometer above ground.	Station, reduced to mean of 24 hours.	Sea level, reduced to mean of 24 hours.	Departure from normal.	Mean max.+mean min.÷2.	Departure from normal.	Maximum.	Date.	Mean maximum.	Minimum.	Date.	Mean minimum.	Greatest daily range.					Total.	Departure from normal.	Days with 0.01 or more.	Total movement.	Prevailing direction.	Maximum velocity. Miles per hour.	Maximum velocity. Direction.	Maximum velocity. Date.						
	Ft.	*Ft.*	*Ft.*	*In.*	*In.*	*In.*	°*F.*	°*F.*	°*F*		°*F*	°*F.*		°*F*	°*F.*	°*F.*	°*F.*	%	*In.*	*In.*		*Miles.*					*0–10*	*In.*	*In.*
Northern Slope.							**25.8**	**+ 2.1**										**72**	**0.94**	**+ 0.1**									**6.0**		
Havre	2,505	11	44	27.27	29.98	−0.07	24.4	+ 3.2	55	8	34	−16	30	14	30	23	20	81	0.77	+ 0.1	6	6,059	sw.	36	sw.	22	11	4	16	6.5	7.0	5.0
Helena	4,110	87	114	25.74	30.06	− .07	27.7	+ 2.9	55	8	35	−11	30	20	35	23	17	65	0.86	+ 0.1	7	6,025	sw.	41	sw.	25	4	15	12	6.4	6.3	1.2
Kalispell	2,962	11	34	26.91	30.07	.00	23.3	− 0.6	46	21	30	−15	30	17	21	22	19	84	2.00	+ 0.2	18	2,528	w.	22	s.	21	2	6	23	8.5	18.1	11.1
Miles City	2,371	26	48	27.44	30.08	− .02	27.5	+ 6.5	50	2	36	−10	31	18	30	23	19	79	0.89	+ 0.3	7	3,747	w.	30	ne.	25	14	11	6	4.1	7.1	3.2
Rapid City	3,259	50	58	26.54	30.07	− .02	29.4	+ 3.4	60	6	41	− 8	30	18	44	23	15	57	0.34	− 0.1	3	5,813	w.	39	n.	22	12	11	8	5.1	3.5	1.6
Cheyenne	6,088	84	101	23.91	30.04	− .05	28.8	− 0.2	58	9	40	− 3	30	18	31	23	16	63	0.41	+ 0.1	7	11,759	w.	72	w.	22	8	12	11	6.0	5.7	1.9
Lander	5,372	60	68	24.58	30.12	− .03	22.9	+ 3.7	55	6	37	−24	31	9	37	18	12	68	1.51	+ 0.8	7	3,029	w.	32	nw.	22	11	15	5	5.2	19.3	8.2
Sheridan	3,790	10	47	26.04	30.09	.....	24.8	.....	62	9	36	−16	30	13	40	20	16	76	0.84	.....	7	3,743	s.	35	nw.	17	12	3	16	6.2	8.3	2.8
Yellowstone	6,200	11	48	23.81	30.14	− .02	19.6	− 2.0	43	9	28	−18	30	11	28	18	14	76	0.89	− 0.9	17	6,957	s.	36	nw.	29	5	8	18	6.8	9.4	7.1
North Platte	2,821	11	51	27.07	30.11	+ .01	28.2	+ 1.6	64	4	40	− 2	27	16	46	23	18	73	0.82	+ 0.4	8	4,701	w.	31	n.	10	13	4	14	5.4	6.1	1.8
Middle Slope.							**35.8**	**+ 2.8**										**68**	**0.39**	**− 0.4**									**4.5**		
Denver	5,291	129	172	24.66	30.04	− .04	33.0	+ 0.8	70	9	46	− 1	27	20	41	25	15	55	0.63	0.0	6	6,022	sw.	46	nw.	23	14	13	4	4.3	10.1	3.0
Pueblo	4,685	80	86	25.24	30.04	− .04	32.6	+ 0.9	72	9	48	− 4	28	17	52	26	17	60	0.35	− 0.1	4	4,730	nw.	40	nw.	25	16	12	3	3.5	4.7	0.8
Concordia	1,392	50	58	28.55	30.07	− .04	33.4	+ 3.9	65	22	42	6	28	24	31	29	26	80	0.40	− 0.1	4	5,572	nw.	36	nw.	18	12	5	14	5.6	2.0	T.
Dodge	2,509	11	51	27.40	30.08	− .02	34.6	+ 3.0	73	22	47	0	28	22	45	28	23	72	0.23	− 0.3	5	6,818	n.	37	n.	26	14	9	8	4.5	1.7	....
Wichita	1,358	139	158	28.55	30.02	− .09	37.6	+ 3.4	65	9	48	7	18	28	30	32	27	70	0.40	− 0.4	4	9,304	s.	52	n.	10	15	5	11	4.8	2.5	....
Oklahoma	1,214	10	47	28.74	30.05	− .06	43.4	+ 4.8	73	9	54	19	28	32	34	36	30	68	0.33	− 1.4	4	10,550	s.	48	n.	24	17	5	9	4.5	T.	....
Southern Slope.							**46.4**	**+ 2.6**										**59**	**0.51**	**− 0.4**									**3.9**		
Abilene	1,738	10	52	28.19	30.03	− .08	49.1	+ 4.1	77	5	62	21	2	36	41	40	31	58	0.77	− 0.4	5	8,422	s.	39	sw.	26	15	5	11	4.7	T.	....
Amarillo	3,676	10	49	26.23	30.02	− .07	40.2	+ 3.8	73	22	54	8	28	27	42	33	27	69	0.13	− 0.7	3	8,275	w.	40	n.	24	22	5	4	3.5	0.2	....
Del Rio	944	64	71	29.04	30.04	− .06	54.0	+ 1.6	79	10	66	28	25	42	38	.....	.....	.....	0.14	− 0.8	4	6,881	nw.	40	nw.	27	12	12	7	4.2	.....	....
Roswell	3,566	75	85	26.36	30.03	− .04	42.1	+ 0.9	70	4	56	1	28	28	43	33	22	51	0.99	+ 0.4	4	5,436	n.	44	nw.	10	10	7	5	3.2	1.5	....
Southern Plateau.							**44.1**	**− 0.8**										**54**	**0.86**	**+ 0.3**									**3.4**		
El Paso	3,762	110	133	26.20	30.02	− .01	44.8	0.0	71	31	58	13	28	32	37	36	24	49	0.43	− 0.1	4	7,686	nw.	54	sw.	31	16	8	7	3.7	0.2	....
Santa Fe	7,013	57	66	23.19	30.06	.00	32.1	+ 1.8	53	7	42	2	28	22	28	25	19	64	0.97	+ 0.2	7	5,936	n.	31	sw.	31	15	9	7	4.3	9.5	3.8
Flagstaff	6,908	8	57	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Phoenix	1,108	76	81	28.84	30.02	− .02	51.6	− 0.3	78	1	63	28	28	40	38	43	33	55	2.54	+ 2.0	6	3,720	e.	25	nw.	26	15	11	5	3.9	.....	....
Yuma	141	9	54	29.87	30.02	− .03	54.4	+ 1.3	79	7	68	28	28	41	34	43	30	46	0.12	− 0.3	2	4,298	n.	35	n.	26	25	4	2	1.9	.....	....
Independence	3,910	11	42	26.01	30.06	− .06	37.4	− 4.2	67	23	50	10	31	25	42	.....	.....	.....	0.26	− 0.5	3	5,070	se.	36	se.	13	14	11	6	....	T.	....
Middle Plateau.							**31.9**	**+ 0.7**										**70**	**1.11**	**+ 0.1**									**5.9**		
Reno	4,532	74	81	25.48	30.10	− .01	36.3	+ 2.6	66	8	47	4	31	26	38	31	24	64	1.09	− 0.6	5	4,533	w.	44	s.	3	10	10	11	5.6	0.5	T.
Tonopah	6,090	12	20	24.05	30.11	.....	31.3	.....	52	23	38	4	31	24	22	27	21	66	0.68	− 0.1	4	7,809	se.	40	nw.	23	13	8	10	5.1	6.4	0.1
Winnemucca	4,344	18	56	25.64	30.12	− .06	30.7	0.0	66	3	41	− 6	31	20	31	27	23	74	1.22	+ 0.2	7	4,788	ne.	32	sw.	3	5	9	17	6.7	3.5	0.3
Modena	5,479	10	43	24.62	30.10	− .02	28.8	− 2.9	58	23	41	−13	30	17	37	24	18	68	0.80	+ 0.2	8	6,517	w.	39	sw.	14	12	9	10	5.1	5.3	4.0
Salt Lake City	4,360	147	189	25.64	30.10	− .03	33.7	+ 1.6	54	4	41	5	31	27	21	29	24	69	1.71	+ 0.4	8	4,355	nw.	48	n.	28	5	8	18	6.8	9.8	5.2
Grand Junction	4,602	82	96	25.42	30.08	− .02	30.2	+ 2.0	55	14	39	10	28	22	27	26	22	76	1.15	+ 0.7	9	3,733	se.	28	s.	14	7	9	15	6.3	15.8	10.0
Northern Plateau.							**32.2**	**+ 0.2**										**75**	**1.58**	**− 0.2**									**6.0**		
Baker	3,471	48	53	26.47	30.16	.00	26.0	− 1.4	51	8	34	−12	30	18	27	25	21	78	1.99	+ 0.5	18	5,189	se.	34	se.	3	2	7	22	8.1	21.9	6.0
Boise	2,739	78	86	27.23	30.16	− .04	33.6	+ 1.4	60	8	41	− 2	31	26	29	30	24	70	1.56	− 0.2	19	4,679	se.	34	ne.	3	4	5	22	7.9	4.0	1.4
Lewiston	757	40	48	29.26	30.09	− .04	36.1	− 1.4	59	21	43	11	30	30	23	.....	.....	.....	0.93	− 0.6	13	3,578	e.	26	s.	24	2	9	20	7.9	2.0	....
Pocatello	4,477	46	54	25.49	30.13	− .06	28.4	0.0	52	7	36	−16	31	20	31	25	20	73	0.99	+ 0.1	14	6,720	se.	34	sw.	23	2	10	19	7.4	5.5	4.0
Spokane	1,929	101	110	27.97	30.08	.00	31.0	+ 0.2	50	8	36	1	30	25	19	29	26	79	2.02	− 0.6	16	4,079	sw.	37	sw.	21	1	6	24	8.4	11.7	1.0
Walla Walla	991	57	65	28.97	30.06	− .06	38.2	+ 2.2	66	8	45	12	30	32	36	34	30	77	1.97	− 0.1	16	3,985	s.	28	s.	19	2	7	22	8.1	5.5	0.8
North Pacific Coast Region.							**42.2**	**+ 0.6**										**85**	**10.21**	**+ 2.3**									**8.3**		
North Head	211	11	56	29.77	30.00	− .03	44.2	− 0.1	54	7	47	29	30	42	9	43	41	88	15.05	+ 7.6	24	16,471	e.	78	se.	19	1	2	28	8.9	0.3	T.
Port Crescent	259	8	53	29.67	29.96	− .02	39.0	+ 0.7	53	20	45	22	30	33	19	.....	.....	.....	9.23	+ 2.4	25	4,085	se.	31	ne.	29	0	9	22	8.5	0.2	0.2
Seattle	125	215	250	29.90	30.03	+ .02	42.0	+ 0.8	56	3	46	24	30	38	15	39	36	82	7.77	+ 1.7	23	7,628	se.	57	sw.	19	1	7	23	8.5	1.0	0.4
Tacoma	213	113	120	29.79	30.02	+ .01	42.0	+ 1.7	62	7	47	22	30	37	20	39	36	82	9.05	+ 1.7	23	4,680	sw.	44	sw.	20	2	9	20	7.7	1.5	....
Tatoosh Island	109	7	57	29.83	29.93	− .03	43.2	− 0.7	52	7	46	30	31	40	10	42	40	88	16.15	+ 1.6	28	15,073	e.	74	s.	20	3	2	26	8.6	0.7	T.
Portland, Oreg	153	68	106	29.89	30.05	− .02	42.0	+ 0.7	55	21	46	26	30	38	14	40	37	85	8.73	+ 1.4	21	4,769	se.	32	w.	28	0	8	23	8.7	T.	....
Roseburg	510	9	57	29.52	30.08	− .03	43.2	+ 1.3	62	2	49	17	30	37	21	41	38	84	5.50	− 0.4	24	2,178	s.	19	n.	29	1	14	16	7.0	T.	....
Middle Pacific Coast Region.							**48.3**	**− 0.2**										**77**	**5.35**	**+ 0.9**									**5.8**		
Eureka	62	73	89	30.02	30.09	− .03	48.4	+ 0.4	65	2	55	28	30	42	24	46	44	83	5.19	− 2.1	19	6,079	se.	38	n.	28	6	10	15	6.5	.....	.....
Mount Tamalpais	2,375	11	18	27.58	30.09	− .03	43.7	− 4.1	59	24	48	23	30	39	18	40	35	76	4.21	+ 0.3	16	16,487	n.	67	nw.	28	10	7	14	5.9	T.	....
Point Reyes Light	490	7	18	29.51	30.03	.....	50.4	− .02	59	7	54	34	30	47	17	.....	.....	.....	5.05	.....	14	15,114	s.	68	nw.	28	12	6	13	5.7	.....	.....
Red Bluff	332	50	56	29.74	30.10	− .04	46.9	+ .05	67	23	52	28	30	42	25	43	38	77	7.48	+ 3.0	10	4,548	nw.	32	se.	12	8	7	16	6.5	.....	.....
Sacramento	69	106	117	30.02	30.09	− .03	47.5	+ 1.2	63	21	54	24	31	41	22	45	41	78	4.42	+ 0.9	9	6,386	se.	35	nw.	30	13	4	14	5.5	.....	.....
San Francisco	155	209	213	29.92	30.09	− .03	32.2	+ 1.3	66	2	58	36	30	47	22	47	42	73	6.42	+ 2.2	9	5,568	se.	40	sw.	3	12	7	12	5.4	.....	.....
San Jose	141	12	110	29.95	30.10	.....	49.1	− 0.8	70	2	58	23	31	40	30	.....	.....	.....	4.37	+ 1.3	8	4,775	se.	40	s.	3	13	5	13	5.2	.....	.....
South Pacific Coast Region.							**53.6**	**+ 0.6**										**69**	**2.87**	**+ 0.7**									**4.2**		
Fresno	327	89	98	29.74	30.11	− .02	48.2	+ 1.4	72	8	57	24	31	39	30	44	39	74	2.78	+ 1.2	7	3,879	nw.	26	nw.	3	11	10	10	4.8	.....	.....
Los Angeles	338	159	191	29.67	30.04	− .03	57.4	+ 0.9	82	24	66	38	31	49	25	49	42	64	2.52	− 0.4	5	4,711	ne.	30	e.	4	19	5	7	3.5	T.	....
San Diego	87	62	70	29.94	30.04	− .03	55.6	− 0.1	76	24	64	40	17	47	24	49	44	71	2.60	+ 0.8	5	3,960	nw.	36	s.	4	17	10	4	3.7	.....	.....
San Luis Obispo	201	32	40	29.88	30.10	− .01	53.2	+ 0.4	80	24	64	29	31	43	40	47	42	69	3.58	+ 1.2	11	3,265	n.	26	se.	3	13	9	9	4.6	T.	....
West Indies.																																	
San Juan	82	8	54	29.93	30.02	− .05	77.2	.....	84	23	82	69	8	73	13	.....	.....	.....	10.24	+ 4.1	20	10,363	ne.	40	ne.	17	8	14	9	5.5	.....	.....
Panama.																																	
Balboa Heights	118	7	97	29.73	29.85	.....	80.1	.....	90	30	87	70	8	73	18	75	74	91	3.59	− 0.8	15	5,328	nw.	24	nw.	22	0	16	15	7.6	.....	.....
Colon	25	5	71	29.83	29.86	.....	80.8	.....	87	21	85	73	3	76	13	77	75	86	9.45	− 2.6	18	8,382	n.	31	ne.	31	11	11	9	5.6	.....	.....

TABLE II.—*Accumulated amounts of precipitation for each 5 minutes, for the principal storms in which the rate of fall equaled or exceeded 0.25 inch in any 5 minutes, or 0.80 in 1 hour, during December, 1915, at all stations furnished with self-registering gages.*

Stations.	Date.	Total duration.		Total amount of precipitation.	Excessive rate.		Amount before excessive rate began.	Depths of precipitation (in inches) during periods of time indicated.												
		From—	To—		Began—	Ended—		5 min.	10 min.	15 min.	20 min.	25 min.	30 min.	35 min.	40 min.	45 min.	50 min.	60 min.	80 min.	100 min.	120 min.
Abilene, Tex.	6			0.61														0.32			
Albany, N. Y.	13–14			2.33														*			
Alpena, Mich.	12–13			0.35														*			
Amarillo, Tex.	31			0.06														*			
Anniston, Ala.	17–18	6:10 a. m.	D. N. a. m.	2.82	10:18 a. m.	10:40 a. m.	0.33	0.11	0.22	0.33	0.52	0.58									
Asheville, N. C.	28–29			2.50														.50			
Atlanta, Ga.	17–18	11:32 a. m.	D. N. a. m.	3.79	2:45 p. m.	3:38 p. m.	.60	.36	.51	.55	.56	.58	0.61	0.63	0.71	0.82	0.90	.97			
					6:34 p. m.	7:13 p. m.	2.22	.12	.23	.34	.39	.43	.46	.54	.60						
Atlantic City, N. J.	13			1.75														.42			
Augusta, Ga.	11			0.85														.45			
Baker, Oreg.	13–14			0.64														*			
Baltimore, Md.	17–18			1.11														.43			
Bentonville, Ark.	31			1.69														.65			
Binghamton, N. Y.	17–18			1.55														.19			
Birmingham, Ala.	28–29			2.63														.41			
Bismarck, N. Dak.	17–18			0.19														*			
Block Island, R. I.	13–14			2.36														.52			
Boise, Idaho.	4			0.30														*			
Boston, Mass.	13–14			1.17														.30			
Buffalo, N. Y.	29			1.34														*			
Burlington, Vt.	25–26			1.02														*			
Cairo, Ill.	14–17			2.45														.29			
Canton, N. Y.	25–26			0.88														*			
Charles City, Iowa.	10–11			0.55														*			
Charleston, S. C.	11			1.37														.60			
Charlotte, N. C.	28–29			1.54														*			
Chattanooga, Tenn.	28–29	4:20 a. m.	8:20 a. m.	3.16	11:29 p. m.	11:44 p. m.	2.26	.24	.33	.40											
Cheyenne, Wyo.	29			0.18														*			
Chicago, Ill.	11–12			0.59														*			
Cincinnati, Ohio.	16–17			2.23														.18			
Cleveland, Ohio.	17			0.38														.18			
Columbia, Mo.	24			0.86														*			
Columbia, S. C.	11			0.89														.45			
Columbus, Ohio.	28–29			1.52														*			
Concord, N. H.	17–18			1.43														*			
Concordia, Kans.	23–24			0.22														*			
Corpus Christi, Tex.	6			0.50														.50			
Davenport, Iowa.	31			0.50														*			
Dayton, Ohio.	16–17			1.16														*			
Del Rio, Tex.	6			0.06														.06			
Denver, Colo.	26			0.27														*			
Des Moines, Iowa.	31			0.16														.14			
Detroit, Mich.	24–25			0.92														*			
Devils Lake, N. Dak.	14–15			0.28														*			
Dodge City, Kans.	24			0.11														*			
Dubuque, Iowa.	16			0.14														*			
Duluth, Minn.	22			0.38														*			
Durango, Colo.																					
Eastport, Me.	14			0.56														.43			
Elkins, W. Va.	16–18			1.67														*			
El Paso, Tex.	5			0.12														.10			
Erie, Pa.	29			1.03														*			
Escanaba, Mich.	16–17			0.74														*			
Eureka, Cal.	1–3			1.97														.62			
Evansville, Ind.	15–17			3.70														*			
Flagstaff, Ariz.																					
Fort Smith, Ark.	16			1.30														.63			
Fort Wayne, Ind.	24–25			0.56														*			
Fort Worth, Tex.	16	1:55 a. m.	3:50 a. m.	0.41	2:11 a. m.	2:22 a. m.	.04	.10	.35	.37											
Fresno, Cal.	2–4			2.29														.40			
Galveston, Tex.	6–7	3:22 p. m.	D. N. a. m.	3.48	9:47 p. m.	10:56 p. m.	.53	.30	.59	.77	.98	1.18	1.46	1.56	1.60	1.64	1.75	1.85	2.06		
Grand Haven, Mich.	12–13			0.23														*			
Grand Junction, Colo.	15–16			0.27														.04			
Grand Rapids, Mich.	18–20			0.42														*			
Green Bay, Wis.	12			0.34														*			
Hannibal, Mo.	15–16			0.92														*			
Harrisburg, Pa.	17–18			1.73														*			
Hartford, Conn.	17–18			1.64														*			
Hatteras, N. C.	25			0.38														.27			
Havre, Mont.	25			0.37														*			
Helena, Mont.	22			0.25														*			
Houghton, Mich.	17			0.50														*			
Houston, Tex.	6–7	3:38 p. m.	D. N. a. m.	3.08	6:06 p. m.	8:50 p. m.	.50	.10	.26	.34	.48	.59	.68	.74	.78	.81	.83				
								.90	.94	.99	1.02	1.05	1.08	1.11	1.19	1.28	1.32				
								1.35	1.38	1.41	1.45	1.60	1.69	1.71	1.77	1.89	2.08				
								2.13	2.22	2.27											
Huron, S. Dak.	15–16			0.40														*			
Independence, Cal.	4			0.17														.06			
Indianapolis, Ind.	24–25			1.58														*			
Iola, Kans.	24			0.58														*			
Jacksonville, Fla.	19–20			3.06														.29			
Kalispell, Mont.	28			0.78														*			
Kansas City, Mo.	24			0.49														*			
Keokuk, Iowa.	10–11			0.48														*			
Key West, Fla.	11			1.22														*			
Knoxville, Tenn.	28–29			2.52														*			
La Crosse, Wis.	16			0.45														*			
Lander, Wyo.	29			0.64														*			
Lansing, Mich.	24–25			0.47														*			
Lewiston, Idaho.	2			0.15														.09			
Lexington, Ky.	16–17			3.75														.46			
Lincoln, Nebr.	16			0.34														*			
Little Rock, Ark.	16			1.58														.48			
Los Angeles, Cal.	4	D. N. a. m.	D. N. a. m.	1.20	1:04 a. m.	1:27 a. m.	.06	.13	.25	.33	.47	.71									
Louisville, Ky.	15–17			5.76														.57			
Ludington, Mich.	12–15			0.46														*			
Lynchburg, Va.	28–29			1.11														.25			
Macon, Ga.	11			0.59														.45			

* Self-register not working.

TABLE II.—*Accumulated amounts of precipitation for each 5 minutes, for the principal storms in which the rate of fall equaled or exceeded 0.25 inch in any 5 minutes, or 0.80 in 1 hour, during December, 1915, at all stations furnished with self-registering gages*—Continued.

Stations.	Date.	Total duration.		Total amount of precipitation.	Excessive rate.		Amount before excessive rate began.	Depths of precipitation (in inches) during periods of time indicated.												
		From—	To—		Began—	Ended—		5 min.	10 min.	15 min.	20 min.	25 min.	30 min.	35 min.	40 min.	45 min.	50 min.	60 min.	80 min.	100 min.	120 min.
Madison, Wis.	16			0.24														*			
Marquette, Mich.	16–20			0.89														*			
Memphis, Tenn.	16–17	3:45 p. m.	10:40 a. m.	1.34	6:04 p. m.	6:20 p. m.	0.02	0.15	0.27	0.37	0.42										
Meridian, Miss.	28	6:40 a. m.	D. N. p. m.	4.37	12:28 p. m.	1:13 p. m.	1.71	.10	.16	.35	.45	0.52	0.63	0.65	0.79	0.87					
					3:44 p. m.	4:19 p. m.	3.03	.10	.23	.32	.42	.51	.58	.63							
Miami, Fla.	25			1.17														0.53			
Milwaukee, Wis.	11–12			0.45														*			
Minneapolis, Minn.	16–17			0.40														*			
Mobile, Ala.	28			2.03														.69			
Modena, Utah.	4			0.26														.12			
Montgomery, Ala.	17	8:25 a. m.	3:15 p. m.	2.97	11:56 a. m.	1:40 p. m.	.36	.08	.24	.35	.50	.77	.90	.92	.98	1.15	1.16	1.35	1.43	2.02	2.32
	28	10:10 a. m.	D. N. p. m.	3.58	7:16 p. m.	7:48 p. m.	2.56	.08	.22	.40	.46	.47	.54	.57							
Moorhead, Minn.	16			0.22														*			
Mount Tamalpais, Cal.	12–14			1.93														*			
Nantucket, Mass.	13			0.97														.46			
Nashville, Tenn.	17–18	7:05 a. m.	D. N. a. m.	1.94	7:24 a. m.	7:51 a. m.	.07	.09	.33	.56	.85	.97	1.01								
New Haven, Conn.	13–14			2.80														*			
New Orleans, La.	17	D. N. a. m.	1:15 p. m.	2.13	7:34 p. m.	7:55 p. m.	1.12	.27	.57	.62	.76	.80									
	28	10:30 a. m.	6:40 p. m.	1.74	2:21 p. m.	3:21 p. m.	.26	.21	.30	.44	.53	.63	.70	.83	1.00	1.19	1.23	1.36			
New York, N. Y.	13–14			1.73														.23			
Norfolk, Va.	28–29			1.21														.47			
Northfield, Vt.	25–26			1.25														*			
North Head, Wash.	6–8			3.65														.36			
North Platte, Nebr.	15–16			0.37														*			
Oklahoma, Okla.	15–16			0.26														.09			
Omaha, Nebr.	16			0.14														*			
Oswego, N. Y.	2–3			1.46														*			
Palestine, Tex.	16–17			1.50														.53			
Parkersburg, W. Va.	16–18			2.79														*			
Pensacola, Fla.	28	10:00 a. m.	1:10 p. m.	1.83	11:46 a. m.	12:50 p. m.	.24	.10	.14	.33	.68	.98	1.13	1.23	1.24	1.25	1.29	1.52	1.59		
Peoria, Ill.	10–11			0.63														*			
Philadelphia, Pa.																					
Phoenix, Ariz.	30–31			1.97														.22			
Pierre, S. Dak.	29–30			0.16														*			
Pittsburgh, Pa.	29			1.11														.21			
Pocatello, Idaho.	28–29			0.37														*			
Point Reyes Light, Cal.	12–13			2.14														.33			
Port Huron, Mich.	24–25			0.77														*			
Portland, Me.	13–14			1.60														*			
Portland, Oreg.	4–5			1.83														.33			
Providence, R. I.	18			1.17														*			
Pueblo, Colo.	15			0.23														*			
Raleigh, N. C.	29			0.49														.34			
Rapid City, S. Dak.	29			0.22														*			
Reading, Pa.	17–18			1.85														.26			
Red Bluff, Cal.	3	1:18 p. m.	1:50 p. m.	0.52	1:31 p. m.	1:46 p. m.	.03	.14	.28	.48											
Reno, Nev.	13			0.61														*			
Richmond, Va.	28–29			0.69														.18			
Rochester, N. Y.	29			0.68														*			
Roseburg, Oreg.	24–25			0.36														.25			
Roswell, N. Mex.	6																	.13			
Sacramento, Cal.	2–3			1.78														.55			
Saginaw, Mich.	24–25			0.38														*			
St. Joseph, Mo.	23–24			0.74														*			
St. Louis, Mo.	24			1.18														*			
St. Paul, Minn.	16–17			0.47														*			
Salt Lake City, Utah.	25			0.62														*			
San Antonio, Tex.	6	4:38 a. m.	11:15 a. m.	1.09	9:36 a. m.	10:06 a. m.	.09	.08	.10	.18	.28	.66	.92								
San Diego, Cal.	4	3:25 a. m.	6:15 a. m.	0.50	3:57 a. m.	4:02 a. m.	.08	.28													
Sand Key, Fla.	11	8:40 a. m.	3:35 p. m.	1.61	9:30 a. m.	9:40 a. m.	.03	.16	.30												
Sandusky, Ohio.	24–25			1.04														*			
San Francisco, Cal.	2–3			3.41														.45			
San Jose, Cal.	3–4			2.80														.68			
San Luis Obispo, Cal.	3–4	5:08 p. m.	3:45 p. m.	2.10	7:04 p. m.	7:17 p. m.	.33	.11	.33	.38											
Santa Fe, N. Mex.	26–27			0.49														*			
Sault Ste. Marie, Mich.	28			0.28														*			
Savannah, Ga.	11			0.54														.40			
Scranton, Pa.	17–18			1.57														*			
Seattle, Wash.	19–21			1.84														*			
Sheridan, Wyo.	9–10			0.28														*			
Shreveport, La.	31			1.16														.55			
Sioux City, Iowa.	16			0.32														*			
Spokane, Wash.	7			0.35														*			
Springfield, Ill.	10–12			0.87														*			
Springfield, Mo.	16			0.77														*			
Syracuse, N. Y.	29			1.23														*			
Tacoma, Wash.	18–21			3.05														*			
Tampa, Fla.	20			1.39														.48			
Tatoosh Island, Wash.	7–8			2.84														.50			
Taylor, Tex.	6	10:44 a. m.	6:30 p. m.	2.18	11:43 a. m.	1:24 p. m.	.10	.13	.16	.19	.25	.32	.43	.64	.78	.85	1.00	1.04	1.13	1.69	1.78
Terre Haute, Ind.	24			1.12														*			
Thomasville, Ga.	17			0.66														.43			
Toledo, Ohio.	24–25			1.14														*			
Tonopah, Nev.	4			0.39														*			
Topeka, Kans.	10			0.68														.31			
Valentine, Nebr.	15–16			0.22														*			
Vicksburg, Miss.	30–31	11:55 p. m.	6:28 a. m.	0.68	1:38 a. m.	1:54 a. m.	.11	.12	.30	.37	.40										
Walla Walla, Wash.	16			0.53														*			
Washington, D. C.	16–18			0.95														.40			
Wichita, Kans.	24			0.21														*			
Williston, N. Dak.	14–15			0.46														*			
Wilmington, N. C.	11			0.71														.26			
Winnemucca, Nev.	13–14			0.95														.07			
Wytheville, Va.	15–16			0.94														*			
Yankton, S. Dak.	15–16			0.45														*			
Yellowstone Park, Wyo.	13–14			0.26														*			

* Self-register not working. † Record partly estimated. ‡ No precipitation occurred during month.

TABLE III.—*Data furnished by the Canadian Meteorological Service, December, 1915.*

Stations.	Pressure.			Temperature.						Precipitation.		
	Station, reduced to mean of 24 hours.	Sea-level reduced to mean of 24 hours.	Departure from normal.	Mean max.+ mean min.÷2.	Departure from normal.	Mean maximum.	Mean minimum.	Highest.	Lowest.	Total.	Departure from normal.	Total snowfall.
	Inches.	*Inches.*	*Inches.*	°*F.*	°*F.*	°*F.*	°*F.*	°*F.*	°*F.*	*Inches.*	*Inches.*	*Inches.*
St. Johns, N. F.	29.48	29.62	−0.21	32.8	+ 4.1	36.4	29.1	49	18	5.45	+0.42	4.0
Sydney, C. B. I.	29.71	29.75	− .14	33.2	+ 5.0	38.1	28.3	51	10	5.84	+1.21	17.0
Halifax, N. S.	29.70	29.81	− .15	32.1	+ 4.5	37.7	26.4	52	11	5.76	+0.64	17.5
Yarmouth, N. S.	29.70	29.77	− .21	33.2	+ 2.5	38.0	28.3	52	17	4.77	−0.27	6.1
Charlottetown, P. E. I.	29.75	29.79	− .15	30.8	+ 6.5	35.0	26.6	48	15	5.06	+1.40	9.6
Chatham, N. B.	29.81	29.83	− .11	27.0	+10.0	32.3	21.8	48	8	4.35	+1.13	23.8
Father Point, Que.	29.87	29.87	− .08	24.2	+ 8.8	28.2	20.3	36	6	3.27	+0.44	29.1
Quebec, Que.	29.60	29.94	− .07	21.4	+ 6.2	26.2	16.1	38	− 3	3.62	−0.07	28.6
Montreal, Que.	29.75	29.97	− .06	23.8	+ 5.5	28.7	18.9	39	5	4.01	+0.36	25.9
Stonecliffe, Ont.	29.38	30.01	.00	17.0	+ 2.0	24.1	9.8	32	−11	1.94	−0.55	19.3
Ottawa, Ont.	29.72	30.06	+ .04	21.0	+ 4.0	27.5	14.5	37	− 8	4.88	+1.97	39.9
Kingston, Ont.	29.68	30.00	− .04	25.6	+ 1.9	32.5	18.8	41	6	2.99	−0.25	13.9
Toronto, Ont.	29.59	29.99	− .06	27.6	+ 0.6	33.0	22.2	41	10	2.52	−0.39	17.5
White River, Ont.	28.64	30.01	+ .04	11.1	+ 1.4	21.7	0.6	31	−18	1.80	+0.09	18.0
Port Stanley, Ont.	29.36	30.02	− .05	27.0	− 1.4	33.1	20.9	48	7	3.50	+1.08	21.5
Southampton, Ont.	29.28			26.5	− 0.2	31.6	21.4	38	6	4.31	+0.33	39.3
Parry Sound, Ont.	29.28	30.01	.00	21.0	− 0.2	28.0	14.0	39	− 2	2.90	−1.58	25.7
Port Arthur, Ont.	29.32	30.05	+ .06	19.5	+ 6.3	27.0	12.0	37	− 6	1.30	+0.43	13.0
Winnipeg, Man.	29.17	30.04	+ .02	11.7	+ 7.6	19.0	4.4	34	−18	1.69	+0.78	16.8
Minnedosa, Man.	28.10	30.01	− .01	9.4	+ 3.7	16.9	1.8	33	−22	0.69	+0.07	6.9
Qu'Appelle, Sask.	27.59	29.93	− .07	12.6	+ 5.2	20.5	4.6	42	−16	0.96	+0.44	8.4
Medicine Hat, Alberta	27.52	29.86	− .11	26.1	+ 7.9	35.2	17.0	53	− 3	0.14	−0.41	1.4
Swift Current, Sask.	27.26	29.93	− .05	20.2	+ 4.2	29.8	10.6	51	−10	1.31	+0.53	13.0
Calgary, Alberta	26.26	29.90	− .04	23.9	+ 4.7	33.8	14.0	51	− 9	0.30	−0.29	3.0
Banff, Alberta	25.23	30.01	+ .07	17.3	− 1.8	25.2	9.4	42	−19	1.53	+0.32	14.5
Edmonton, Alberta	27.48	29.84	− .09	19.0	+ 5.9	27.9	10.0	41	− 6	0.54	−0.16	5.4
Prince Albert, Sask.	28.28	29.92	− .09	8.1	+ 5.3	16.4	− 0.2	32	−20	1.15	+0.41	11.5
Battleford, Sask.	28.13	29.95	− .04	11.5	+ 6.1	19.6	3.3	40	−13	0.20	−0.12	2.0
Kamloops, B. C.	28.72	30.04	+ .10	29.6	+ 0.7	35.1	24.1	47	− 2	1.60	+0.82	13.8
Victoria, B. C.	29.70	29.96	− .01	41.4	+ 0.2	45.0	37.8	51	27	4.78	−3.20	0.2
Barkerville, B. C.	25.50	29.90	+ .02	20.0	− 0.9	25.7	14.3	39	− 7	4.85	+1.68	43.5
Hamilton, Bermuda	29.91	30.08	− .04	61.6	− 3.1	66.8	56.5	71	49	2.88	−1.61	.....

Chart I. Hydrographs of Several Principal Rivers, December, 1915. XLIII—132.

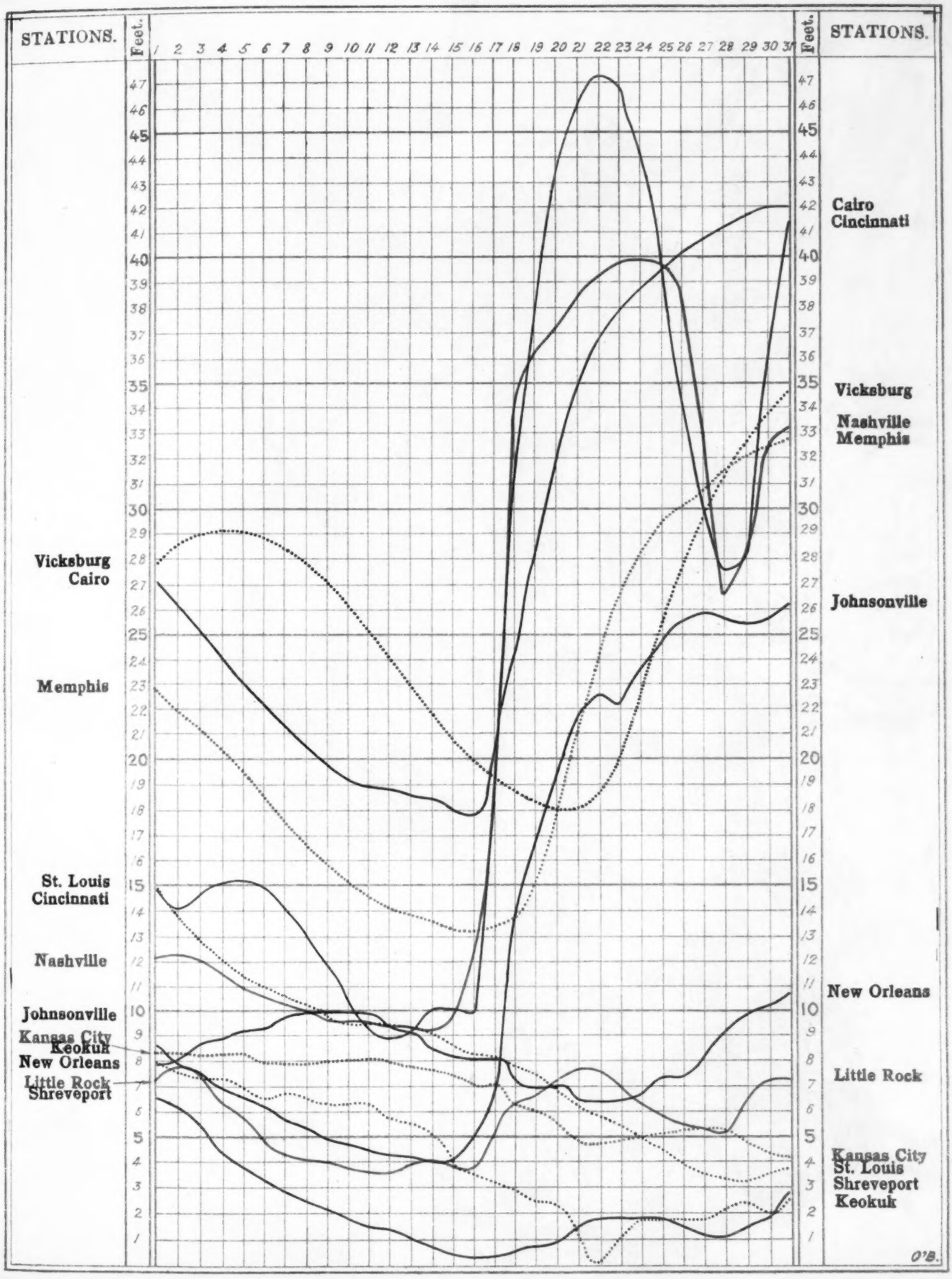
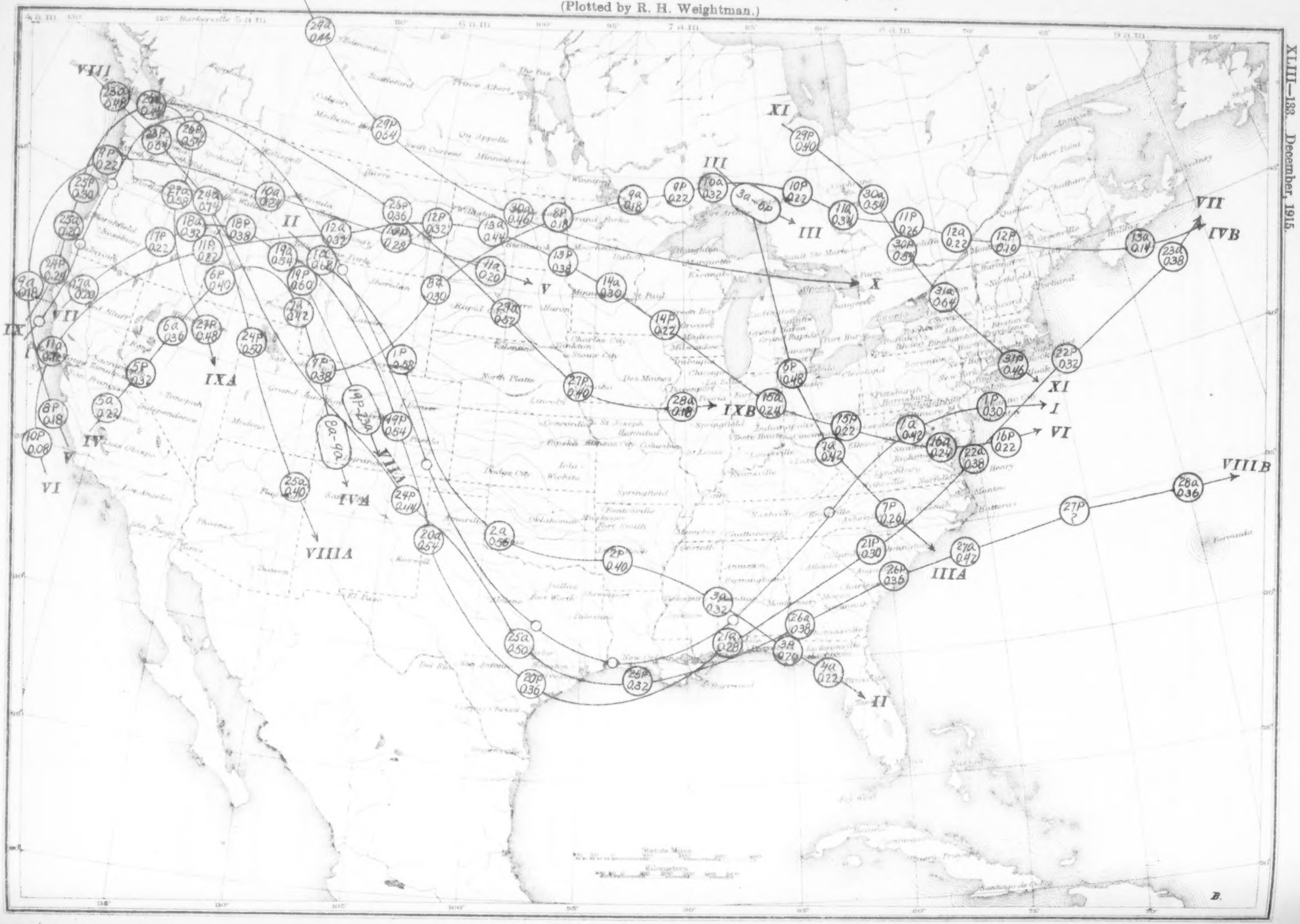


Chart II. Tracks of Centers of High Areas, December, 1915.

(Plotted by R. H. Weightman.)



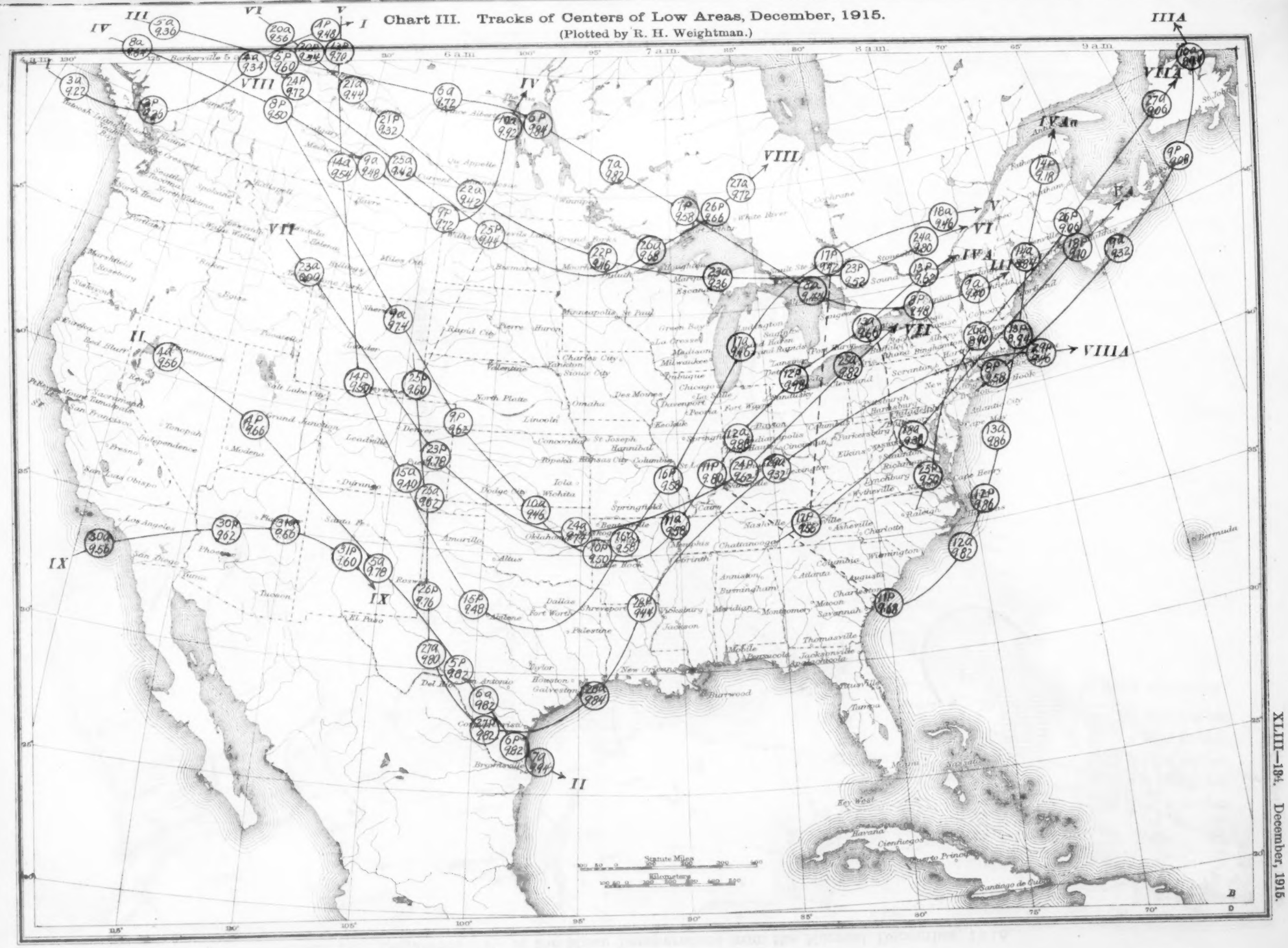


Chart III. Tracks of Centers of Low Areas, December, 1915.
(Plotted by R. H. Weightman.)
Statute Miles
Kilometers

Chart IV. Departure (°F.) of the Mean Temperature from the Normal, December, 1915.

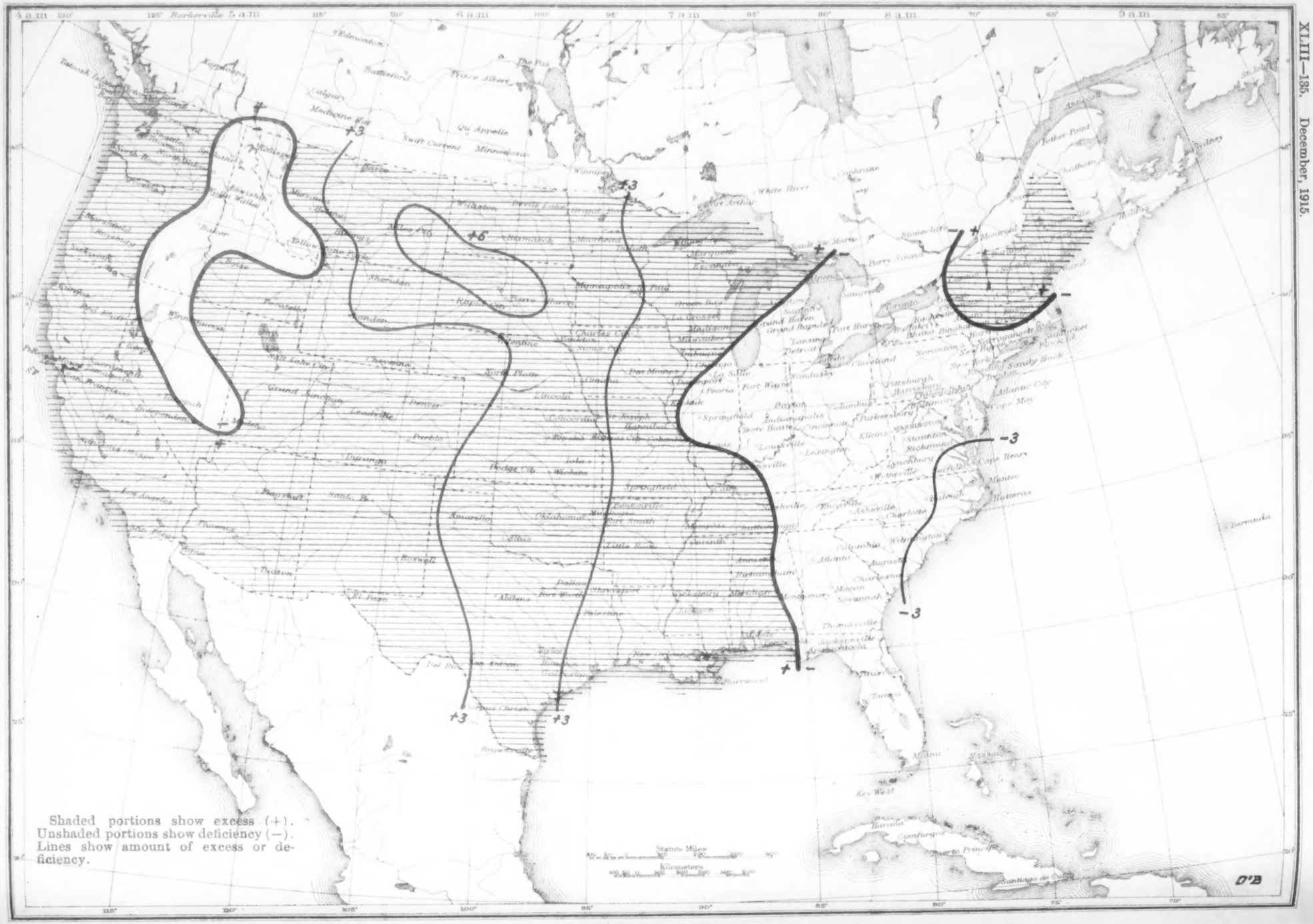


Chart V. Total Precipitation, December, 1915.

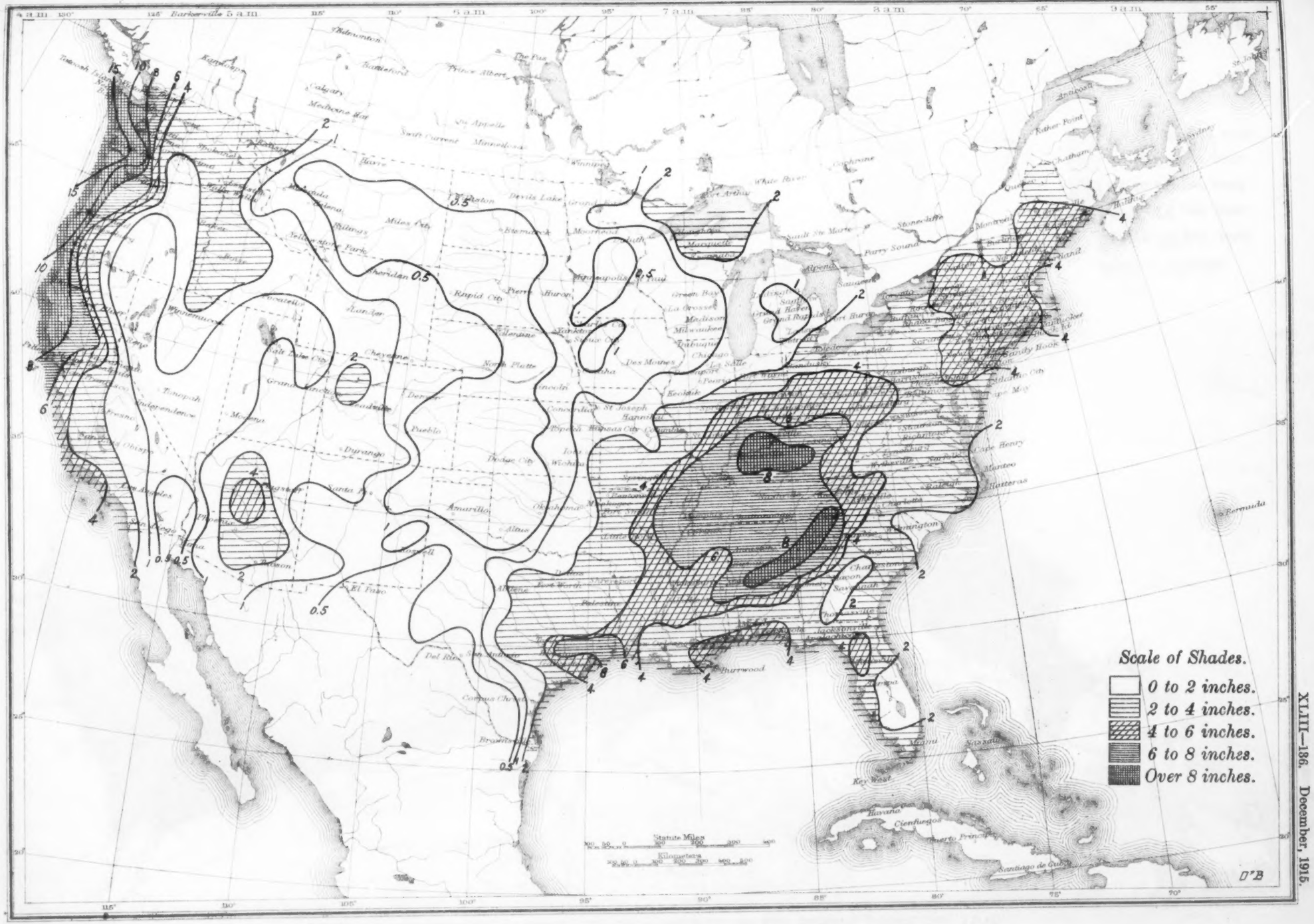


Chart VI. Percentage of Clear Sky between Sunrise and Sunset, December, 1915.

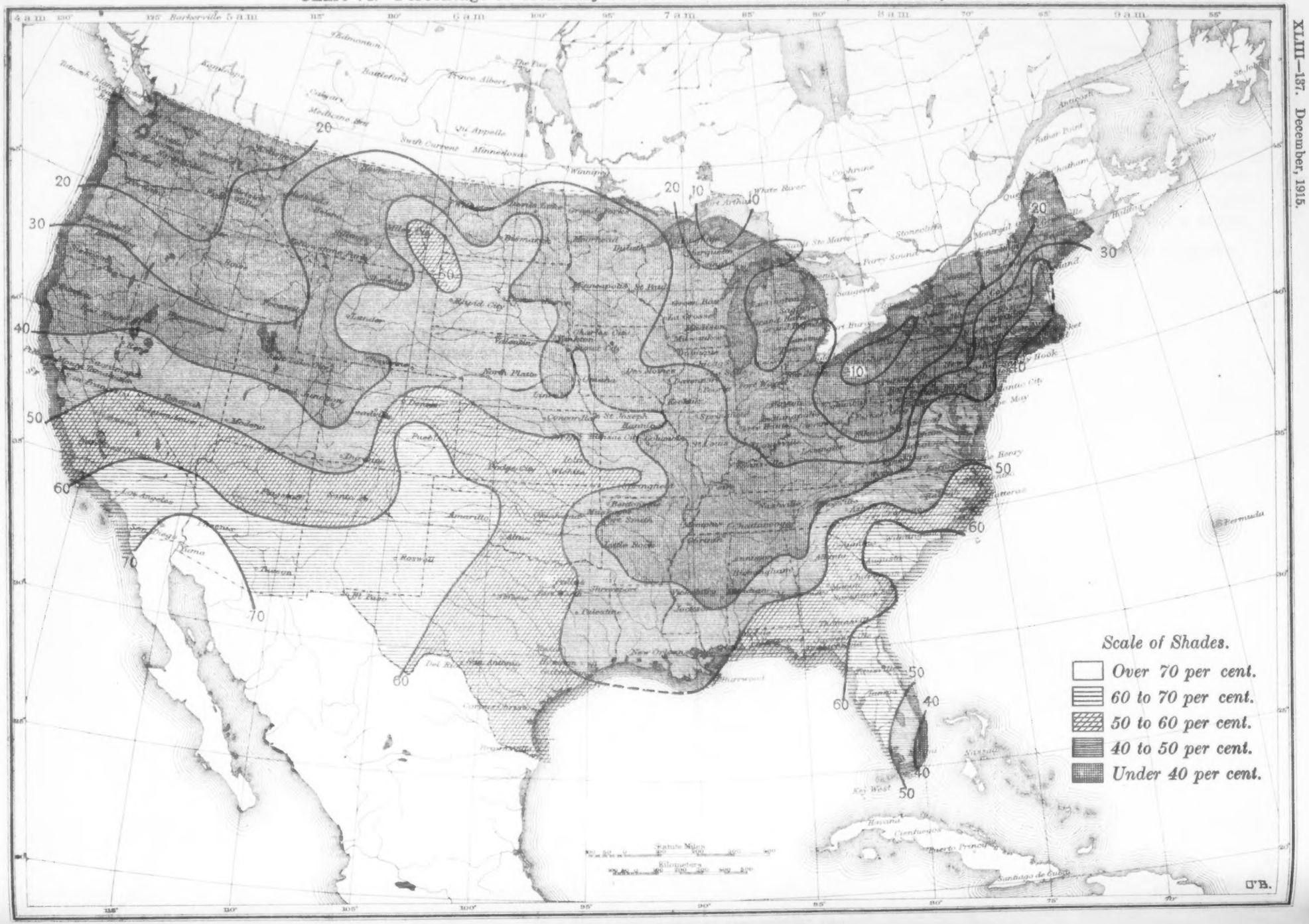


Chart VII. Isobars and Isotherms at Sea Level; Prevailing Winds, December, 1915.

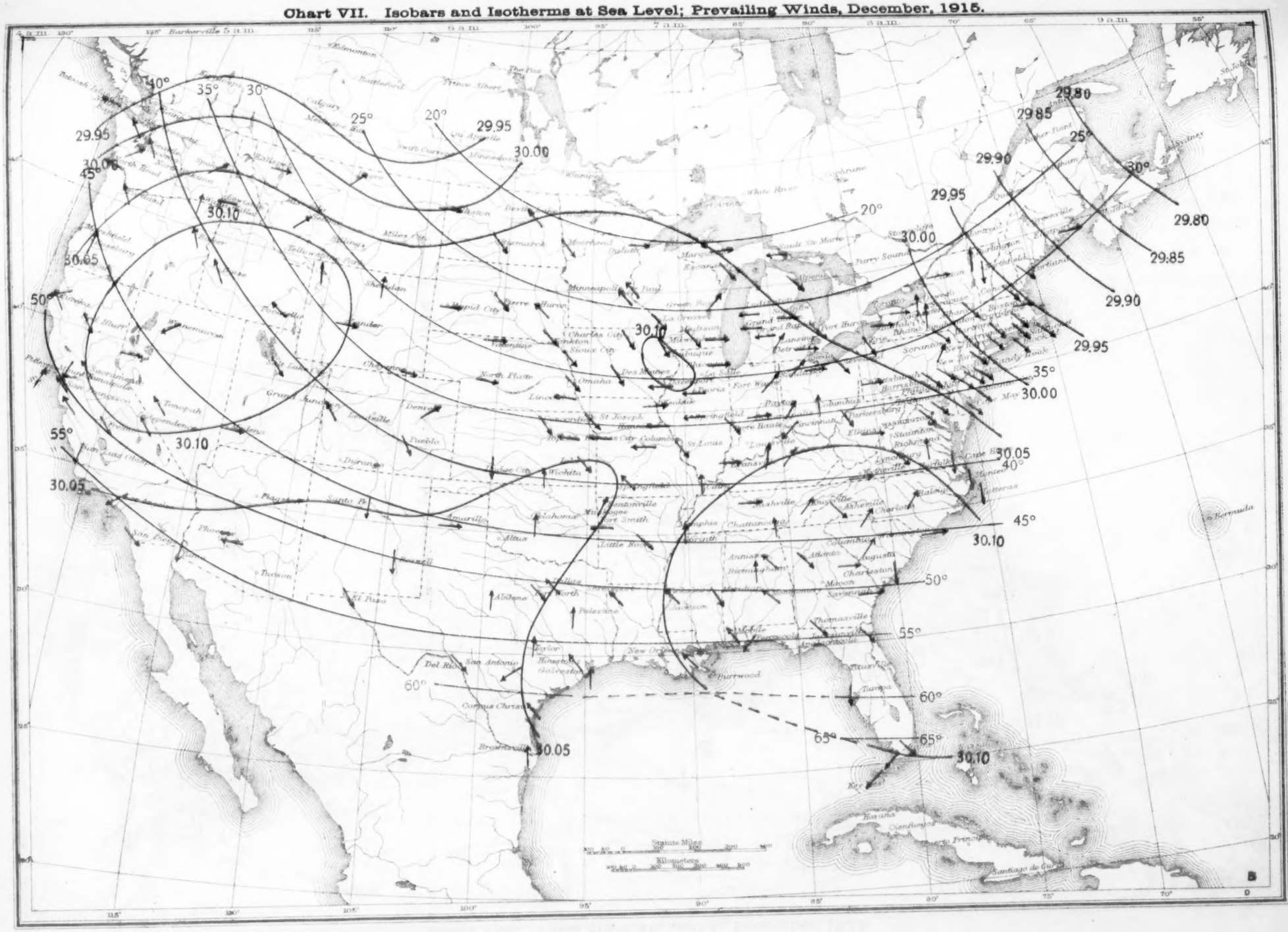


Chart VIII. Total Snowfall, Inches, December, 1915.

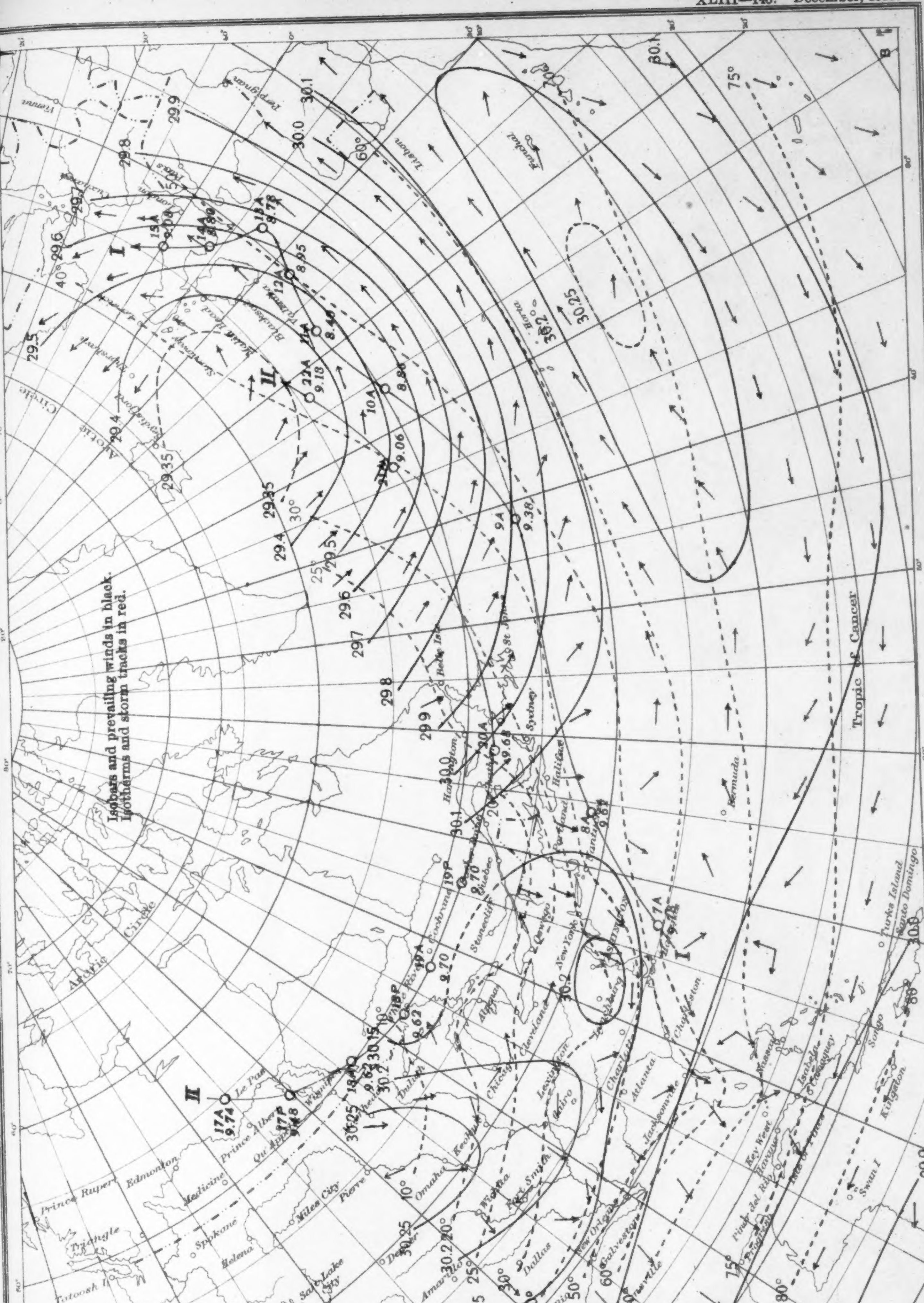


Chart IX. Means of Meteorological Data for North Atlantic Ocean, December, 1914.

W. J. H. 1. **Earthquake frequency in the United States, 1915.**

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